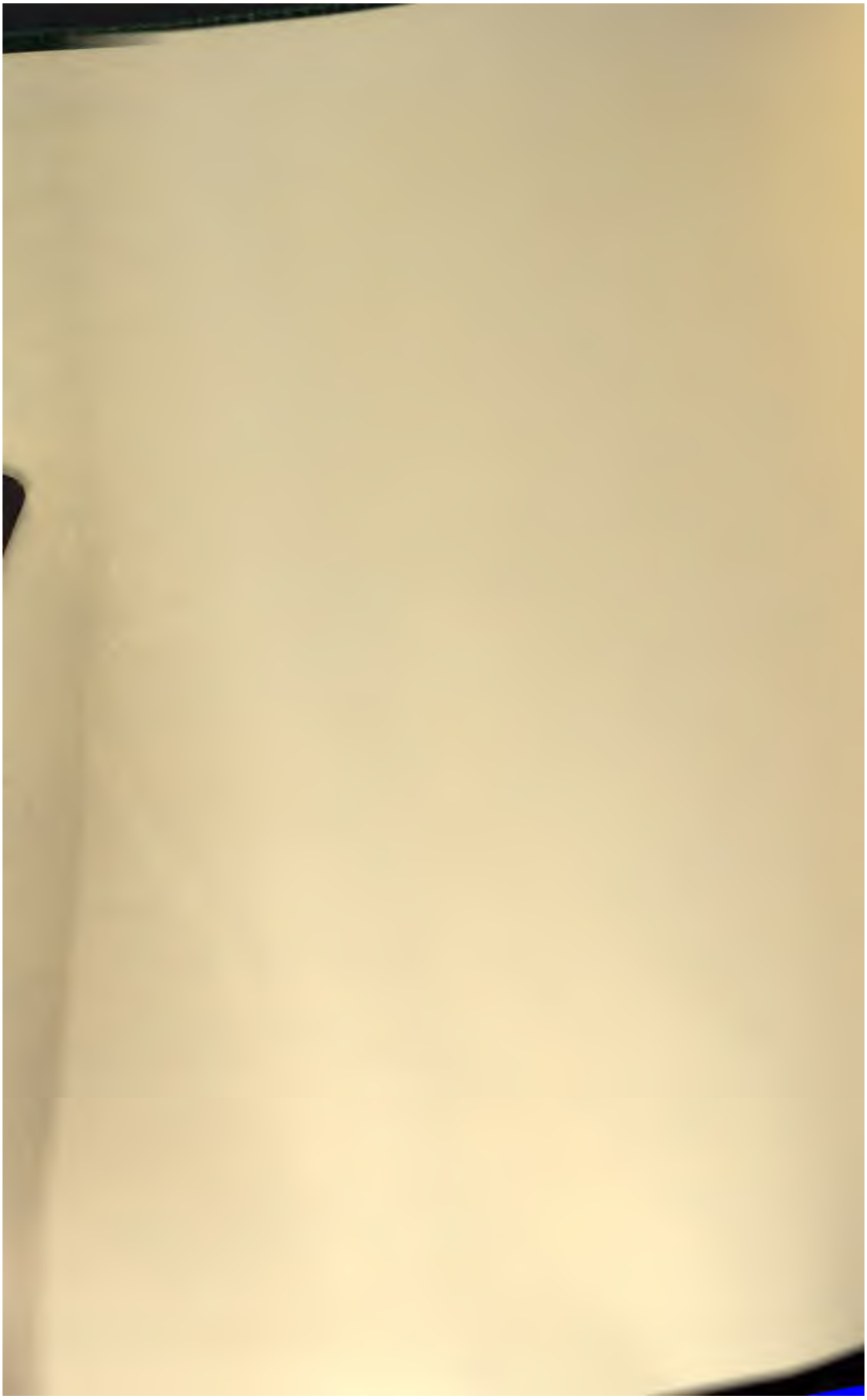

WASHINGTON GEOLOGICAL SURVEY

HENRY LANDES, State Geologist

BULLETIN No. 14

A Preliminary Report on the Quincy Valley Irrigation Project

By HENRY LANDES, A. W. MANGUM, H. K. BENSON,
E. J. SAUNDERS AND JOSEPH JACOBS

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LETTER OF TRANSMITTAL.

Governor M. E. Hay, Chairman, and Members of the Board of Geological Survey:

GENTLEMEN: I have the honor to submit herewith a report entitled "A Preliminary Report on the Quincy Valley Irrigation Project," by Henry Landes, A. W. Mangum, H. K. Benson, E. J. Saunders, and Joseph Jacobs, with the recommendation that it be printed as Bulletin No. 14 of the survey reports.

Very respectfully,

HENRY LANDES,
State Geologist.

University Station, Seattle, July 1, 1912.

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ILLUSTRATIONS.

INTRODUCTION.

By Henry Landes, *State Geologist.*

The Quincy Valley Irrigation Project, as at present outlined, involves a tract 36 miles by 30 miles in area, located in central Washington. The western boundary of the proposed irrigable area is Columbia River; the northern and southern limits are the highlands represented by Badger and Saddle Mountains, respectively; while the eastern boundary is placed arbitrarily in this report at the line between ranges 28 and 29. The amount of surface involved in this area of 1,080 square miles is 691,200 acres. The studies that have been made of the soil conditions and the topography have made it clear that of the above acreage at least 450,000 acres are readily irrigable, while the Wenatchee water supply is known to be ample to serve an area of at least 435,000 acres. The conversion of this large area, by far the most of it of a truly desert character, into an oasis of rare productiveness, capable of readily supporting a happy population of 100,000 people, is a matter of more than state-wide prominence, and is by far the greatest project ever proposed for the development of the state's material resources.

PRELIMINARY SURVEYS.

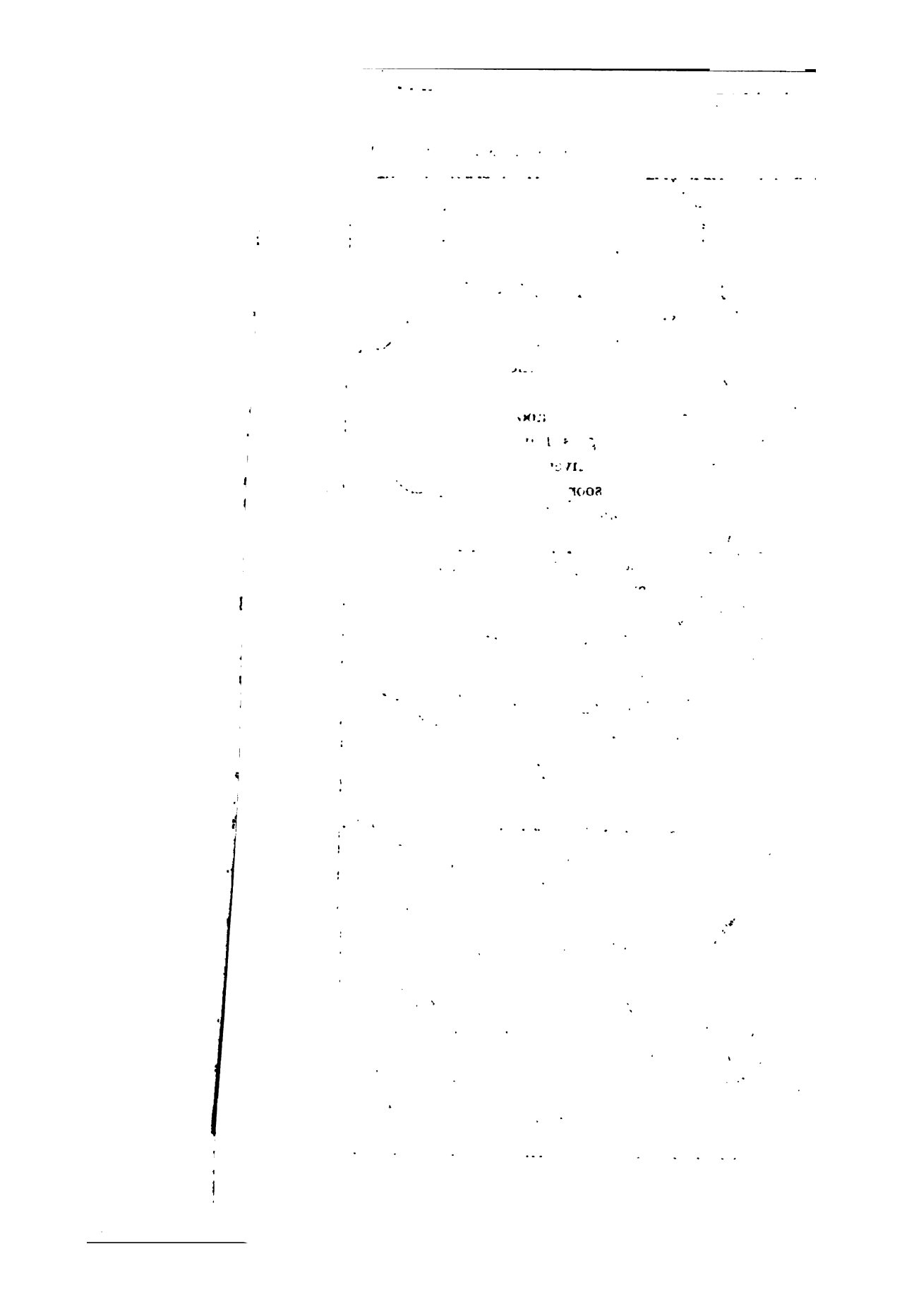
The Board of Geological Survey, at its meeting in Olympia on April 16, 1909 ,recognizing the great importance to the state of the Quincy Valley Irrigation Project, directed the State Geologist to arrange for co-operative work with the U. S. Geological Survey whereby topographic surveys might be carried on in the region in question and the country accurately mapped. Accordingly five quadrangles were mapped, viz., Quincy, Winchester, Moses Lake, Beverly and Red Rock. These have been combined on Plate 1 of this report, and it will be noted that the five quadrangles cover practically all parts of the project except four townships in the southeast corner. In a similar fashion, by co-operation with the Bureau of Soils, U. S. Department of Agri-

culture, soil surveys were made of the whole area. The different types of soils were studied and mapped, and determinations made of the percentage of alkali. A complete report will soon be issued by the Federal Bureau of Soils, containing ample descriptive matter, chemical analyses, colored maps, and all information necessary in regard to the nature of the soils embraced in the project.

In addition to the above lines of work the Wenatchee and Malaga quadrangles, lying along the line of the proposed canal from Wenatchee River to Quincy, are now being surveyed and these maps will soon be ready for use. The proposed reservoir site about Wenatchee Lake has been very carefully surveyed in detail and a topographic map prepared with 5-foot contours. A gaging station has been maintained on the lower Wenatchee River for some years and careful measurements made of the run-off of that stream. Every effort has been made by the Board of Geological Survey, with the resources at its command, and in co-operation with the Federal Bureaus, to secure necessary information bearing upon the project.

FUTURE SURVEYS.

Before the cost, as well as the complete feasibility, of such a great engineering enterprise can be determined beyond a question, it is necessary that a number of additional surveys and investigations be made. There are many questions regarding the size, location and character of the dam at the foot of Wenatchee Lake that can be settled only by careful detailed surveys. The whole route of the canal from the intake to the distributing point must be carefully studied and mapped. In particular the crossing of Columbia River will necessitate months of investigation to satisfy all the inquiries which will arise concerning such a great engineering feat. The whole scheme of distributing the water, the location of the main laterals and tributaries, will necessitate spending months of time in field surveys. In addition to all these and many other things, the entire 1,080 square miles must be examined in great detail, down to very small subdivisions to de-



termine the exact amount as well as location of the irrigable lands.

STATE AID.

It seems clear to the writer that the state should undertake the investigations and surveys just mentioned, in addition to those already made as a result of state aid. There are several reasons why the enterprise commends itself to state support. In the first place, as shown on Plate 1, there are over 31,000 acres of state land embraced in the project. Of this it is safe to say that at least 20,000 acres are irrigable. If the general story of irrigation in Washington holds true here, in its first year under water this land would be worth not less than $300 per acre; while its value after a few years, especially if fruit or alfalfa were grown, would enhance to $750 or $1,000 per acre. The story of the state lands under irrigation would be repeated for all the other lands of the project. The land which now sells generally for $15 or $20 per acre would easily become 30- or 40-fold more valuable under a successful scheme of irrigation. The profit to the state, not only in the increase of taxable property, but in the strong impulse given to every industry, and in the material advancement of its citizens, would be almost incalculable.

It is the estimate of Mr. Jacobs, in his report, that the lands of Quincy Valley can be irrigated for $100 per acre. Except for a few small irrigable tracts, it is altogether unlikely that in this state any scheme of irrigation will ever be placed in operation where the cost per acre will be less than $100. Furthermore, about all of the smaller irrigable areas have been reclaimed, so that in the future the irrigation schemes will necessarily embrace larger tracts than ever before, involving far greater capital. It becomes more and more apparent that in carrying out the larger irrigation enterprises either state or federal aid must be sought after. This seems especially necessary in the Quincy Valley Irrigation Project because it is not a case where the work can be done in sections and the land put under water as desired, but where the whole irrigation scheme must be completed before any of the land can receive benefit.

While the cost per acre to irrigate the land is moderate and a charge which the land would easily and readily assume, yet the large acreage involved makes the total engineering cost so high that the whole sum of money involved seems stupendous. In any plan of bonding, however, where the repayment of the cost is extended over a period of 20 or 30 years, the annual charge per acre is small and even insignificant when contrasted with the earning power of the land.

ACKNOWLEDGMENTS.

For this bulletin articles have been contributed by Mr. A. W. Mangum, Prof. H. K. Benson, Prof. E. J. Saunders and Mr. Joseph Jacobs. Mr. Mangum has had charge of the soil surveys and in this report submits a brief abstract of his full account, which will be ready for distribution about December 1, 1912. Prof. Benson has selected samples of the typical soils of the valley and in his article gives their analyses, as well as a brief discussion of soil characteristics. A more complete chemical report accompanies the soil report above mentioned. Applications for the fuller report, with descriptive matter, colored maps, analyses, etc., should be made to the Bureau of Soils, U. S. Department of Agriculture, Washington, D. C., or to the State Geologist, University Station, Seattle, Washington.

Prof. Saunders has submitted a report upon the general weather and climatic conditions of Quincy Valley. This is a topic of great importance in considering the nature of the crops that may be grown. Mr. Jacobs, who has given this irrigation project much attention, and who is well informed about every phase of it, has prepared an important article upon the engineering problems involved. He has gone into the subject as thoroughly as possible with the data at his command. It will be recognized by everyone that any engineering report at this time is wholly preliminary, and that many months of detailed work will be necessary before the final plans and estimates can be submitted.

SOILS OF QUINCY VALLEY.

By A. W. Mangum.*

The soils of the Quincy area may be separated broadly into six groups: (1) The compact fine sandy and silt loams that cover the underlying basalt to a depth of from 10 to more than 30 feet; (2) the sandy and fine sandy loams underlain at an average depth of from 2 to 6 feet by a thin layer of limestone which in turn rests upon the basalt; (3) the stony and gravelly soils underlain by compact deposits of gravel and rounded bowlders; (4) the areas of drifting sands; (5) the rough stony lands; and (6) the recent alluvial soils.

The soils of the first group occupy a large area in the northwestern part of Quincy Valley. The finer textured types, consisting of a silt loam, a silty fine sandy loam, and a fine sandy loam, occupy a large area southwest of Quincy and also the greater proportion of the country surrounding that town. A large area of the silty fine sandy loam belonging to this group occurs south of Frenchman Hills, embracing the northern part of T. 16 N., ranges 25 and 26 E., and the southern part of T. 17 N., ranges 25 and 26 E. There is a large area of sandy loam occupying the country around Morrison postoffice, which is also included in this group. In this particular locality the soils are underlain by a compact deposit of sands and fine gravel.

The soils of this group have a deep compact subsoil and when thoroughly cultivated are among the most productive types in the area. South and southeast of Quincy, they become more sandy, and the surface becomes more hummocky, as the loose sandy soil has been drifted into series of small mounds and ridges with shallow basins intervening. The level topography of this group as a whole makes these types well adapted to irrigation. Where dry farming is practiced, wheat and rye are the principal crops grown. The average yield of wheat is

*Bureau of Soils, U. S. Department of Agriculture.

about 8 or 10 bushels per acre, but yields of 20 to 25 bushels per acre have been secured during favorable seasons. When irrigated, these soils produce very profitable yields of melons, potatoes, small grains, and fruits. Oats and alfalfa have also been successfully grown on a limited acreage of irrigated land.

The soils of the second group occupy a large area north of Frenchman Hills, in the vicinity of Burke. Another large area occurs between Frenchman Hills and lower Crab Creek Valley, occupying a large proportion of the level to gently rolling uplands between Low Gap and Beverly. They consist of compact fine sandy loams and fine sands, underlain at a depth of from 12 inches to 6 feet by a thin layer of limestone. In some localities the shallow surface soils have been almost entirely removed by the action of winds, and the underlying limestone occurs so near the surface that the weathered material is frequently turned up with the plow. The topography of the soils of this group varies from almost level to very gently rolling, and the greater proportion of the area occupied by them lies well for irrigation.

During a favorable season they produce very good yields of small grains, but the crops grown on the more shallow areas, where the underlying limestone occurs within 3 feet of the surface, are usually damaged by drought, as the shallow soil is unable to conserve a sufficient amount of moisture. The small areas under irrigation have demonstrated that under favorable moisture conditions, the soils of the second group are very productive.

The soils of the third group occupy a large area south and southwest of Ephrata, embracing the greater part of the country around Moses Lake. They consist of sandy loams and fine sandy loams which contain a variable amount of gravel and small bowlders. It is usually necessary to remove a large quantity of stones from the surface before the land can be profitably cultivated, and in some localities small areas occur which are of such a stony character as to make cultivation impracticable. Areas occur, however, throughout the region occupied

by these types where the surface soils, to a depth of 12 to 15 inches, are comparatively free from either gravel or small bowlders. The soils are underlain to a considerable depth by a compact deposit of gravel and small, rounded bowlders, which insures good natural drainage. Some of the best orchards in the area are located on these soils and when irrigated and thoroughly cultivated the trees do exceedingly well. The irrigated areas produce very profitable yields of all crops grown in Quincy Valley.

The soils of the fourth group consist of loose incoherent sands and fine sands which have been drifted into mounds and ridges by the action of winds. These soils occur south of Moses Lake and north of Frenchman Hills, extending westward to a point within a few miles of Burke postoffice. The loose structure of the soils causes the surface material to be constantly shifted by the wind, and the open porous character of the subsoil causes the natural drainage to be excessive. A large proportion of this land could be irrigated and utilized for agricultural purposes, although there would probably be a considerable loss of water by seepage, and the hummocky topography would make it very difficult to get the land into suitable shape for irrigation. There is a large area of sand dunes included in this group, which are of little or no agricultural value. These dunes occur principally south and southwest of Moses Lake. The topography of this region consists of high, rounded dunes with shallow "pot holes" or basins intervening, or long, narrow ridges with troughlike valleys between them. These topographic features make it impracticable to attempt the irrgation and agricultural development of this region, as the dunes and ridges have a height of from 20 to more than 60 feet and the loose sandy soils are being shifted continually.

The fifth group comprises the extensive areas, locally known as "scab lands," and the precipitous, rocky bluffs which border the valleys of Crab Creek and the Columbia River. The larger areas of "scab land" border the valley of Crab Creek. They consist of small areas of sandy soil, varying from a few square

rods to several acres in extent, occurring at intervals over more extensive areas whose surface consists mainly of bare rock outcrop. Only a shallow covering of soil rests upon the bed rock and large quantities of rock fragments are frequently scattered over the surface or mixed with the sandy soil. A large proportion of these "scab lands," however, consists of areas of bare outcrops of basaltic rock.

The rough stony lands found along the northern slope of Saddle Mountain and the bluffs bordering the valley of Columbia River are too steep and rocky to be of any agricultural value. Small areas occur throughout the "scab lands" where the sandy soil has a sufficient depth to enable it to be used for agricultural purposes, but these areas are of such limited extent and are surrounded by such extensive areas of non-agricultural lands that it is impractical to attempt to irrigate them.

The sixth group embraces the recent alluvial soils lying along the courses of Columbia River and Crab Creek. Many of these soils have been modified to some extent by materials deposited on the surface by the wind. Along Columbia River the alluvial soils occupy a comparatively level strip of land between the steep bluffs of the adjacent uplands and the channel of the stream. The soils consist of fine sands, sandy loams, and gravelly sandy loams. The subsoils are uniformly composed of compact masses of rounded, waterworn gravel, which insures good natural drainage. The areas occupied by these soils have only a slight elevation above the level of the stream at high water, but with the exception of a small area bordering the river, none of the land is subject to overflow. A few small areas occur where gravel and small, rounded cobbles are present in sufficient quantities to interfere with cultivation, but these areas are of small extent and the greater proportion of this land is well adapted to agriculture. The topography varies from level to gently undulating and a very large percentage of these alluvial soils could be irrigated and developed agriculturally without difficulty. The soils occupying the narrow valley bordering the channel of Crab Creek consist principally of sandy loams,

gravelly sandy loams, and clay loams. They are, as a whole, poorly drained and frequently contain alkali in harmful amounts.

The failure to secure profitable yields in Quincy Valley is often due as much to the drifting of the dry sandy surface soils as to the lack of a sufficient amount of soil moisture to mature the crops. This is true of almost every type of soil suitable for agricultural purposes. On many of the more sandy types the soil is blown away from the roots of the plants while the crops on adjacent fields are covered by shallow sand drifts. Where irrigation is practiced extensively, trees, to serve as windbrakes, should be set along the fence lines or ditches.

Most of the soils are at present entirely free from any harmful accumulation of alkali. Small areas occur, however, in Crab Creek Valley, in the bottoms of Willow Creek and several other large coulees, and in the deep depressions or pot holes surrounded by areas of rough stony lands where the soils contain as much as two-tenths of one per cent. to more than three per cent. of alkali. The majority of these alkali areas are of very small extent and occupy low depressions or poorly drained basins which receive the drainage water from the surrounding lands.

The soils over the remainder of the valley are at present free from alkali, but if any extensive acreage were put under irrigation a more thorough drainage system would be necessary in many localities to prevent the accumulation of harmful salts. If the seepage water were allowed to collect and evaporate in the shallow depressions which occur at intervals over almost every type of soil, there is danger that these poorly drained areas would eventually contain enough alkali to injure crops.

CHEMICAL ANALYSES OF THE SOILS OF QUINCY VALLEY.

By H. K. Benson.*

Much stress in the past has been placed upon the chemical composition of soils. More recently the efforts of soil chemists have been directed toward showing that soil fertility is more largely a matter of control or soil management. This assumption is based upon the belief that the chemical elements become available for plant growth only under certain conditions which it is necessary to obtain and maintain during the growing period. These conditions may be broadly stated as a proper physical condition of the soil at to fineness and crumbling or tilth; sufficient moisture or water holding power; a suitable temperature; and the absence of certain plant poisons or toxic substances secured by crop rotation.

Nevertheless there has been a rather close relationship between the chemical compostion of soils and the specific crops which have been found especially prolific. For example, the soils of the Palouse region are high in phosphoric acid and are also well adapted for grains, while in the fruit belt of central Washington the soils are usually high in the content of potash.

The manner in which chemical elements enter into the mechanism of plant growth is not fully understood. It has come to be generally recognized that the mineral elements in the soil which are of the most interest to the agriculturist are calcium, potassium, phosphorus, and nitrogen. For technical reasons these are generally spoken of as lime (calcium oxide), potash (potassium oxide), phosphoric acid (phosphorus pentoxide) and nitrogen. These constituents are the ones which it is thought to add to the soil in commercial fertilizers.

The action of lime is probably quite complex in most cases, neutralizing any acids which might be present, inducing a much better flocculation, or crumbling of the soil, improving its tilth,

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aeration etc., which functions are most important for the growth of desirable kinds of bacteria in the soil, especially those kinds which gather nitrogen from the air and grow in association with leguminous crops as alfalfa, vetch or clover. It is possible also that lime may have a specific effect on some plants and it is held by many fruit growers that an ample amount of lime will cause the production of a sweeter fruit. Potash is believed to be of especial importance in the production of starch in growing plants, and phosphoric acid to be important mainly in the formation of seeds or grain, although undoubtedly having other functions in the growing plants. Nitrogen is believed to be taken from the soil, mainly in the form of nitrates, and is elaborated or made over in the plant into various substances, especially the proteids, substances which are best known in the muscular tissues of animals. No substance in the soil produces a more rapid or decided response in the crop than does nitrogen. A ready supply of nitrates is of the utmost importance to green crops, especially during the periods of most rapid growth, and it is desirable to have nitrogenous organic substances in the soil to furnish nitrates by the process of decay, especially for crops other than leguminosae.

The six groups of soils noted below may have certain typical compositions assigned to them. It is of course, evident that no two samples of any one soil will give the same analytical results on account of the variations which exist in the history of a soil. All that can here be done is to represent within reasonable limits the approximate composition of the respective groups as determined by the analyses of a number of carefully selected and typical samples. The interpretation of a soil analysis is also a matter of some difficulty. Agricultural chemists vary in their manner of classifying a given soil as good or poor.

Hilgard in his text book (page 377) states the average composition of virgin soils taken from arid regions as follows: lime 1.43%; phosphoric acid 0.16%; potash 0.67%; and loss on ignition 3.15%. Professor Maercker of the Halle Experimental Station, Germany, has formulated a classification which often

serves as a guide in judging the capabilities of a soil (under a proper system of management) from the analysis of the virgin or uncultivated soil.

Grade of Soil	Potash	Phosphoric acid	Lime in sandy soil	Total nitrogen
	Per cent.	Per cent.	Per cent.	Per cent.
Poor Soil	Below 0.05	Below 0.05	Below 0.05	Below 0.05
Normal Soil	0.15—0.25	0.10—0.15	0.15—0.20	0.10—0.15
Rich Soil	Above .40	Above .25	Above .30	Above .25

CHEMICAL COMPOSITION OF THE QUINCY SOILS.

Group I. Fine sandy and silt loams.

Lime .....1.00—1.15%
Phosphoric acid.....0.08—0.13%
Potash .....0.30—0.45%
Loss on ignition.....4.00—6.00%

Group II. Sandy and fine sandy loams.

Lime .....1.20—1.30%
Phosphoric acid.....0.04—0.12%
Potash .....0.30—0.90%
Loss on ignition.....2.80—4.40%

Group III. Stony and gravelly soils.

Lime .....1.02—1.20%
Phosphoric acid .....0.10—0.15%
Potash .....0.37—0.46%
Loss on ignition.....4.30—4.90%

Group IV. Drifting sands.

Lime .....0.50—1.00%
Phosphoric acid .....0.03—0.07%
Potash .....0.30—0.35%
Loss on ignition.....1.10—2.60%

Group V. Stony soils from "Scab" land. (No analyses.)

Group VI. Recent alluvial soils.

Lime .....0.91—0.96%
Phosphoric acid .....0.10—0.13%
Potash .....0.48—0.80%
Loss on ignition .....1.70—4.00%

Inasmuch as all of the soils were either light colored or gave a low loss on ignition (except those containing calcium carbonate), it was apparent that generally speaking the soils are deficient in nitrogen and very few determinations of this element

were made. One of the first steps in improving the agricultural value of the virgin soils of this region will therefore consist in supplying organic and nitrogenous matter to the soil by the usual method of green fertilization.

The following table gives the analytical data and geographic location of a portion of the samples analyzed:

LOCATION	Lime	Phosphoric acid	Potash	Loss on Ignition
Section 19, Tp. 20 N., R. 23 E.	0.70%	0.14%	0.31%	4.80%
Section 16, Tp. 16 N., R. 23 E.	0.91	0.13	0.48	1.70
Section 25, Tp. 16 N., R. 28 E.	1.04	0.09	0.43	3.70
Section 33, Tp. 16 N., R. 26 E.	1.63	0.19	0.87	6.20
Section 20, Tp. 19 N., R. 24 E.	0.91	0.11	1.00	3.90
Section 35, Tp. 17 N., R. 24 E.	1.27	0.05	0.25	2.80
Section 23, Tp. 19 N., R. 27 E.	1.02	0.04	0.42	4.80
Section 27, Tp. 20 N., R. 26 E.	0.96	0.08	0.42	4.90
Section 26, Tp. 18 N., R. 23 E.	1.29	0.137	0.316	4.40
Section 8, Tp. 20 N., R. 24 E.	1.06	0.12	0.50	6.10
Section 26, Tp. 20 N., R. 24 E.	0.95	0.07	0.35	3.00
Section 31, Tp. 19 N., R. 24 E.	1.13	0.07	0.31	1.10
Section 34, Tp. 29 N., R. 23 E.	0.88	0.11	0.41	4.70
Section 1, Tp. 16 N., R. 26 E.	0.95	0.119	0.273	3.80
Section 6, Tp. 18 N., R. 26 E.	1.04	0.10	0.33	2.40
Section 20, Tp. 16 N., R. 26 E.	1.15	0.04	0.23	2.00
Section 16, Tp. 17 N., R. 25 E.	0.47	0.08	0.31	2.60
Section 27, Tp. 19 N., R. 24 E.	0.98	0.10	0.40	4.00

CLIMATE OF QUINCY VALLEY.

By E. J. Saunders.*

CLIMATIC CONDITIONS.

The Quincy Valley, situated east of the Cascade Mountains in the Columbia River Basin, although in the same latitude, and not far removed from Puget Sound Basin, has a climate as different from that west of the mountains as if it were in an entirely different part of the continent. The influences of the topography and of the prevailing winds are remarkably well shown here. This area is practically shut off from the moderating effects of the ocean winds by the high Cascades to the west, and it also lacks the protection of these mountains from the continental extremes of climate, especially the cold waves of winter that spread from the east over this section of the country. But being near the ocean the westerly winds prevent, or break up, the cold waves so that this section is not subject to the prolonged winter conditions or heavy snows to which the states of the middle west in the same latitude are exposed.

The interception of the moist ocean winds by the Cascade Mountains gives this valley a very low annual precipitation, and the region of which it is a part is called the arid belt of the state. The air in its forced ascent loses most of its moisture on the western slope and near the summit of the Cascades, and in descending the eastern slope it is dynamically warmed so that it blows over the Quincy Valley as a dry wind, able to take up moisture rather than to cause precipitation.

PRECIPITATION.

The average annual precipitation for the Valley is less than eight inches. Of the Weather Bureau Stations which supplied data for this report, Wenatchee has the greatest average rainfall, 14.33 inches, and Kennewick the least, 6.34 inches. (See table.) This very low precipitation, as compared with that on the western slope of the Cascades, as already stated, is ac-

*Assistant Professor of Geology, University of Washington.

counted for by the fact that the air is cooled to such an extent by forced ascent in passing over the Cascade Mountains that the greater part of its moisture is deposited on the western slopes. In descending the eastern slopes the air is dynamically warmed by increase of pressure at lower levels, and its capacity for moisture rapidly increases, thus favoring clear skies and scant precipitation. As a result of this decided change in relative humidity the annual rainfall gradually decreases as the air seeks lower levels toward the Columbia River, and Quincy Valley may be considered as located in the rain shadow of the Cascade Mountains.

The monthly distribution of rainfall as shown on Plate IV is of greater importance than the average annual precipitation. In Quincy Valley a wet season from November to March, inclusive, and a dry season from April to October, inclusive, prevails and shows the effect of proximity to the western coast. But the contrast between the two seasons is much less marked than on the coast, and the summer months usually show a secondary maximum rainfall period in May and June, but not with as heavy precipitation as the winter months. This increased precipitation in May and June is very favorable to dry farming, and is a great aid to all lines of agricultural development of the country.

The winter maximum is accounted for by the larger number and greater activity of the cyclonic or storm areas during that season, the movement of the warm moist air from the ocean over a cooler continent, and the fact that although deprived of most of its moisture in its passage over the Cascade Mountains, the air is cooled to a still lower temperature in moving towards the interior and thus yields additional precipitation. The secondary summer maximum is explained by the occurrence of summer convectional or thunder storms, causing heavy showers and occasional cloudbursts in this section. These showers bring the summer average up much higher in comparison to the winter average than it is on the coast, and as we go farther inland we find the summer precipitation greater than the winter precipitation. In this particular case then we have evidence of the two con-

trols, the oceanic with a winter maximum, and the continental with a summer maximum, the former being more pronounced because of the proximity of the Valley to the Pacific Coast.

The average snowfall throughout the Valley is from 10 to 24 inches, but is higher for some of the stations used in the table, e. g., Wenatchee having 63.4 and Ellensburg 29.2 inches. The greatest snowfall recorded at Wenatchee is 114.5 inches, while at Kennewick the highest is 19.5 inches. Occasionally a winter will pass with scarcely any snow at the southern and lower stations. The snow remains on the ground for a comparatively short time and thus is not a very important factor in the general climatic conditions of the Valley.

A rather important factor in the climate of Quincy Valley, especially in the ripening and coloring of fruits and grain, is the great number of clear days. The average year will consist of about 190 clear days, 79 partly cloudy days, 96 cloudy days, and only 36 days on which more than .01 inches of precipitation may be expected. Thus there will be at least 270 days per year with abundant sunshine, and of the remainder a number recorded as cloudy will be only partly so.

TEMPERATURE.

The mean annual temperature of the Valley is about 50 degrees and there is a very slight difference for the various stations. But this tells us little about the yearly temperature conditions. It is from the study of the annual, monthly and daily ranges that we get some idea of the true temperature conditions.

The average temperature for the coldest month varies from 25.3° at Ellensburg to 31.2° at Kennewick, giving a winter average for the district of about 27°. The average for the warmest month varies from 77.3° at Wahluke to 72.1° at Odessa, giving a summer average of about 75° for the district. This would give an average yearly range of 48° for the region or more than twice as great a range as in western Washington, where the difference from season to season is about 20°.

The highest and lowest temperatures recorded at the various stations often show an absolute annual range of 110° or from

100° to -10°, and temperatures have been registered as high as 106° at Ephrata, 107° at Wahluke, and 115° at Kennewick, and as low as -21° at Kennewick and -29° at Ellensburg. These extremes occur only during very hot spells of summer and cold waves of winter and are of short duration. On account of the low relative humidity of the air the temperature extremes are not felt to the same extent as if the air were moist, and during the warmest weather the nights are cool and pleasant, and in the coldest spells of winter the days are bright and clear.

The cold waves of winter are due to the extension of high pressure areas, with their low temperatures, from the northeast over this region, and are usually accompanied by a slow drift of air from that direction. The warm waves of summer are also due to the pressure of a well developed high barometer area to the east, causing the highly heated air from the interior to move westward over this region. These warm spells are frequently broken by strong winds from the west causing a rapid fall in temperature.

The daily range of temperature is high, especially in the summer months, with an average daily range of about 35° and a somewhat lower range in the winter months of about 15°.

The explanation of the high annual, monthly and daily ranges of temperature is, first, the slight moderating influence that the ocean winds exert here on account of being intercepted by the Cascade Mountains; second, the fact that this district lacks the protection of high mountains from the extremes characteristic of the interior; third, the air, deprived of most of its moisture in passing over the Cascades, is usually clear and allows of much greater radiation of heat during the night and during the winter, thus increasing the daily and annual range of temperature.

KILLING FROSTS.

The dates on which first and last killing frosts occur, being governed by the passage of well developed high pressure areas, will vary considerably from year to year. The dates in the table give approximately the times between which frosts may be expected at any station. In general the higher uplands are sub-

ject to frosts earlier and later than the lower areas, but frequently the low flat valleys will have heavy frosts when the adjacent slopes and uplands are free from frost because of the drainage of the cold heavy air down the slopes and its collection in the lower valleys.

In some sections of the district frost may be expected as early as September 15, while in other parts it is not liable to occur before October 20. On the other hand frosts have occurred as early as August 23 at Ephrata, September 10 at Odessa, and October 7 at Trinidad.

The latest frosts in the spring may be expected at Trinidad about April 5, at Odessa about May 17, and at Hatton about May 25; but killing frosts have occurred at Trinidad as late as April 17, at Odessa as late as June 3, and at Hatton as late as June 15.

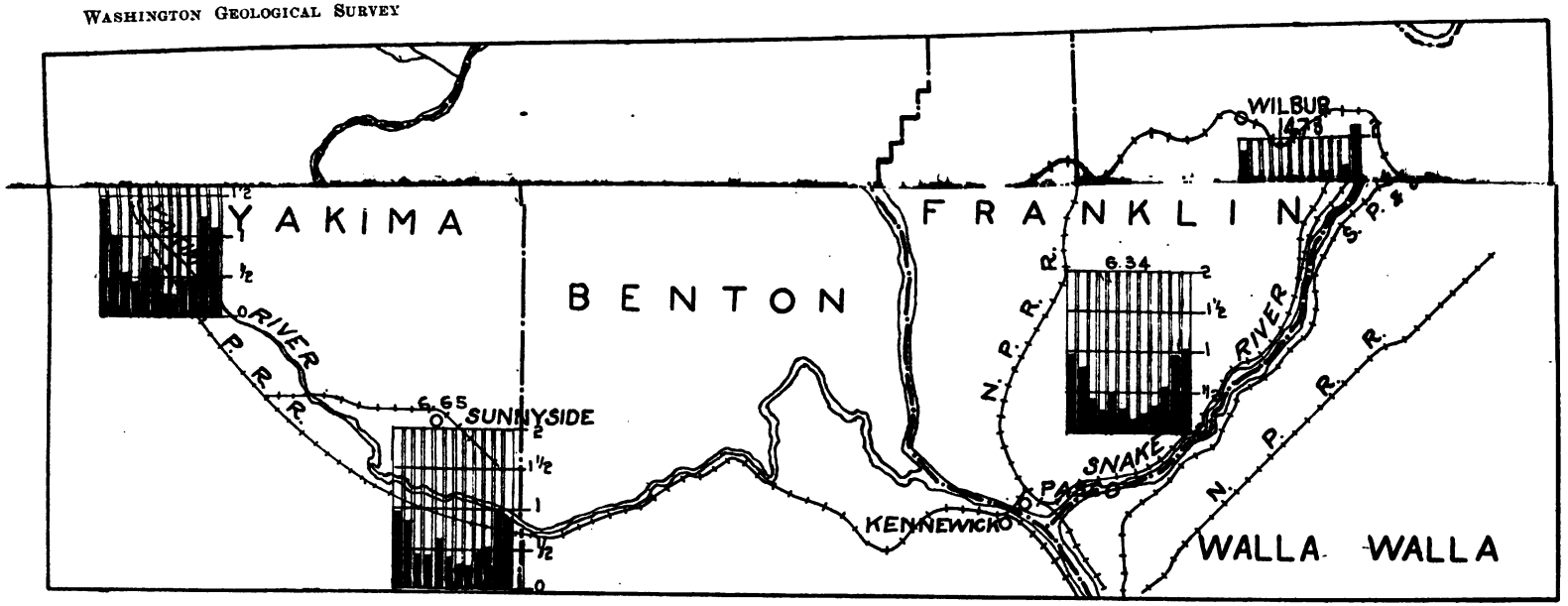
TABLE A. CLIMATIC CONDITIONS IN CENTRAL WASHINGTON.

	Elevation	Total precipitation in inches	Snowfall	Days with more than .01 inches precipitation	Cloudy days	Partly cloudy days	Clear days	Latest frost	Earliest frost	Days without frost
	Feet		Inches							
Ephrata	1,265	7.71	12.0	80	94	87	197	Apr. 23	Sept. 28	158
Ellensburg ...	1,570	9.79	29.2	61	92	68	205	May 23	Sept. 21	121
Hatton	1,100	9.14	13.5	67	120	83	162	May 25	Sept. 8	106
Odessa	1,540	.....	.....	.....	104	101	146	May 17	Sept. 25	116
Trinidad	900	6.56	23.8	32	67	79	219	Apr. 5	Oct. 20	198
Wahluke	410	6.85	11.5	34	94	80	185	Apr. 21	Oct. 4	166
Wenatchee ... (near)	1,169	14.33	63.4	82	103	90	172	Apr. 30	Oct. 21	174
Kennewick ...	367	6.34	10.8	48	78	90	198	Apr. 28	Oct. 15	170
Sunnyside ...	740	6.65	8.2	50	106	73	186	May 7	Oct. 8	154

WINDS.

The prevailing direction of the winds varies considerably at different stations, due to topographic irregularities, but in general the winds are either west, northwest, or southwest, and only occasionally from an easterly direction, when they bring with them the cold spells of winter or the warm waves of summer.

During the fall and spring months, occasional strong and disagreeably cool dry winds blow from the mountains over the


YAKIMA
BENTON
FRANKLIN
WALLA WALLA
WILBUR
1478
6.34
6.65
SUNNYSIDE
KENNEWICK
SNAKE
RIVER
N. P. R. R.
P. R. R.
2
1½
1
½
0

plains toward the east, the direction at different stations depending somewhat on the local topography. The air seems to glide rapidly down the eastern slope of the mountains after several warm days, and the winds will continue to blow for several days at a time, often attaining a velocity of thirty or forty miles an hour. When the winds first begin, usually along about noon, or late in the afternoon, the temperature will fall 10° to 30° in a short time and the first part of the blow often creates a dust storm. The winds are quite a relief after a few days of real hot weather, which in summer they frequently follow.

During the winter months there is very little strong wind, but occasionally, following the passage of a cyclonic area to the east, the air, moving into it from the southwest, comes down the eastern slope of the Cascades and is warmed dynamically by increased pressure, due to its forced descent. Having lost most of its moisture as it passed over the mountains, it blows over the valleys east of the mountains as a warm, dry wind called the "Chinook," often causing the sudden breaking up of a cold stormy spell of weather and rapidly melting or vaporizing any snow or ice that may be present.

SUMMARY.

The climate of this section of the Columbia River Basin seems to be the result of a combination of oceanic, continental, and mountain influences. The winter maximum of rainfall, the fact that the summer warm waves and the winter cold waves are not as severe, nor of as long duration as those farther east, are evidences of the oceanic influence. The high temperatures of summer, the low temperatures of winter, and the summer maximum of rainfall in May and June, which is of immense importance to the wheat growing sections of the country, are all interior characteristics. The clear, dry, exhilarating air and the strong mountain winds, are the results of the situation of the section on the east slope of the Cascade Mountains.

These conditions all combine to give the Quincy Valley one of the best agricultural climates on the continent, although the low rainfall makes irrigation necessary for the most advantageous crops and for fruit growing.

IRRIGATION PROBLEMS OF THE QUINCY VALLEY PROJECT.

SOURCE OF WATER SUPPLY, STORAGE, DELIVERY AND DISTRIBUTION, DUTY OF WATER, LENGTH OF IRRIGATION SEASON, COST DATA, ETC.

By JOSEPH JACOBS.*

In complying with the request of the State Geologist that I prepare a chapter on the engineering aspects of the Quincy Valley Project, I would point out that in a pamphlet of this character, intended as it is for general distribution and largely for lay readers, a purely technical discussion of engineering problems would be manifestly out of place, and I do not feel at liberty to consider these matters as exhaustively as was done in my initial report on the project to the Quincy Valley Water Users' Association.

Furthermore, a comprehensive engineering consideration of any irrigation project embraces far more than mere detail of construction and design, dealing as it necessarily must with soils, crop and climatic conditions, with water-supply, water-rights and transportation, and in fact with all those elements which affect the commercial as well as the physical feasibility of the project.

No attempt therefore will be made to record here, in detail, all the engineering data that have been secured in pursuit of the studies of this project, and such presentation as is here made will be confined to a general description of what the scheme contemplates, a discussion of its more important engineering features and a recital of the character of the investigations that have thus far been made.

The writer has been concerned with the study of this project since the fall of 1909 when he was requested by the Quincy Valley Water Users' Association to make an investigation and to render a report upon the most feasible and economical source of

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water supply for irrigation of the so-called Quincy Flats. Except as limited by the funds available for the work, no restrictions were imposed as to the scope of the investigation and he was therefore permitted to and did in fact examine every possible source of water supply that might be brought into service for these lands. These possible sources were as follows:

1. Pend d'Oreille River and Pend d'Oreille Lake.
2. Spokane River and Coeur d'Alene Lake.
3. Columbia River.
4. Moses Lake and Crab Creek.
5. Ground water and artesian supply.
6. Wenatchee River and Wenatchee Lake.

Of the water supply sources above listed it is my purpose to discuss in detail only the one finally adopted, namely Wenatchee River and Wenatchee Lake, but before proceeding with that I would state briefly the causes which lead to the abandonment of the other supplies.

Nos. 1, 2 and 3 were abandoned by reason of prohibitive cost, though incidentally No. 2 was also rendered untenable by reason of the complicated water-right situation involved.

No. 4 was abandoned by reason of its entire inadequacy to serve a project of the magnitude contemplated, though for a project of lesser magnitude, or under certain conditions to serve a small portion of the proposed project, it was well worthy of consideration.

No. 5 was abandoned on account of the uncertainty of the supply, on account of its inadequacy to serve the area contemplated for irrigation, and finally because the capitalized value of the annual maintenance cost for pumping was, except for low lifts, in excess of the estimated ultimate cost involved in the gravity scheme adopted.

Serious consideration was given to this scheme of pumping from ground waters, by reason of the ease and cheapness of its initial installation and the fact that development could proceed as rapidly or slowly as general business conditions seemed to warrant.

In my initial report this matter was discussed at length and in detail, and I believe showed conclusively that, for the irrigation of an area as large as that contemplated in this project, it would be foolhardy to depend upon an artesian supply, the existence of which has not been proven and which in all probability does not exist, or upon pumpage from a ground water supply whose quantity and extent is at best conjectural.

Despite my positive views, however, as to the final insufficiency of this source of water supply, I recognize the practical aspects of the present installation of wells, where the pumpage lift is not excessive, in that such development serves to establish the agricultural excellence of the district and to enhance land values, and because these installations may be replaced with the gravity supply when the same becomes available.

This now brings us to a discussion of the project proper as dependent upon the Wenatchee source of water supply.

CHARACTER OF INVESTIGATION.

The investigations thus far made are as listed below and have been wholly of a reconnaissance nature, unless otherwise stated.

1. An examination of the irrigable area as to topography and soil characteristics.
2. An examination into the character of land ownership.
3. An examination of water-rights on Wenatchee Lake and Wenatchee River.
4. An examination of route of main canal.
5. An examination of Wenatchee River for possible dam sites.
6. An actual survey of the Lake Wenatchee reservoir site.
7. An examination and compilation of all available data, published and unpublished, of the hydrography of the streams involved and of the topography of the lands involved in the project.

LOCATION.

The lands to be irrigated are situated in Grant county, in the north central part of the state (see map), and are embraced in the territory roughly bounded as follows: On the north

by the Great Northern Railway, on the east by Moses Lake, on the south by Crab Creek and the Chicago, Milwaukee & Puget Sound Railway, and on the west by the Columbia River. The tract described contains about 550,000 acres of which it is estimated that about 80 per cent. is irrigable and it is also estimated that there is sufficient water for about that amount of land.

TOPOGRGAPHY.

The lands vary in general altitude from about 700 feet above mean sea level along their southerly extremity to about 1,300 feet above mean sea level along their northerly extremity, with, however, a narrow zone of higher land in between. Extending easterly and westerly across the valley, along a line about nine miles from the southerly boundary and about eighteen miles from the northerly boundary, there is a low, sandy ridge known as Frenchman Hills, which at certain points along its crest rises to elevations of from 1,700 feet to 1,900 feet above mean sea level, the lowest point in the ridge being only 1,500 feet above mean sea level. Along the easterly edge of the tract the lands slope gradually to the level of Moses Lake, at an elevation of 1,038 feet, while along its westerly edge the general plateau elevation is maintained to the rim of the Columbia River bluffs where it drops abruptly to the river grade at an approximate elevation of 600 feet above mean sea level. The main body of irrigable lands, namely that lying northerly from Frenchman Hills, constitutes a slightly rolling plateau practically free of marked surface irregularities, while to the southward the lands slope rapidly but with fair regularity from the Frenchman Hills to the low basaltic bluffs immediately facing Crab Creek bottoms.

Not all of these lands are irrigable, certain areas being classed as non-irrigable, by reason of their being too steep, as along the Columbia River bluffs, or too high for gravity irrigation as are the higher portions of the Frenchman Hills, and certain small areas also would be classed as "scab land," i. e., having such surface exposure of rock as to render their reclamation impracticable.

SOIL.

This has been made the subject of a special chapter which will be found in another part of this bulletin and I will therefore state here but a few words in relation thereto. As to quality the soil may be classified as a basaltic loam, a type of soil characteristic of a great portion of central Washington and universally recognized as of high value. It appears to be somewhat heavier, but in kind related to the soil of the Yakima Valley, and perhaps even more nearly identical with that of the Sunnyside District, which alone would prove its fertility. As indicated by a great many wells already put down for domestic and irrigation purposes the soil depth varies generally from 25 feet to 100 feet or more.

CLIMATE.

This too has been made the subject of a special chapter and I shall therefore say only a brief word in relation thereto. Like all central Washington this region has insufficient rainfall to insure profitable agriculture without irrigation. The warm moisture laden winds of the Pacific are nearly sapped of their water vapor in passing over the Cascade Mountains, so that there is a wholly deficient precipitation for successful agriculture when the Columbia River Valley proper is reached.

The irrigable area under consideration has long summers with very warm days and cool nights, and winters that are not excessively cold. The nearest Weather Bureau stations are at Ephrata, at an elevation of 1,265 feet, and Trinidad, at an elevation of 900 feet, near the eastern and western boundaries, respectively, of the project, these stations having been established in 1903. On account of Trinidad being somewhat under the general upland level and on the slope dropping down to the Columbia River, the record at Ephrata is more nearly representative of the climatic character of the entire Quincy Valley and in deducing the table which follows a little further on, a slightly greater weight was given to the record of that station.

As best indicative of the character of climate enjoyed by Quincy Valley it is of interest to compare its more important

climatic features with those of the Wenatchee, Sunnyside and Yakima districts, which are in neighboring territory and all of which have already won fame for their exceptional adaptability to fruit culture and for the resulting high values of land attained.

In the following table all data were deduced from published records of the United States Weather Bureau and are intended to include only those factors which have direct bearing upon agriculture and irrigation.

TABLE B. MEAN WEATHER CONDITIONS—VARIOUS STATIONS. (a)

ITEM	Quincy Valley (b)	North Yakima	Sunnyside	Wenatchee (near)
Elevation above sea level	1,200′	1,000′	764′	1,169′
Length of record (years) (c)	4 to 8	12 to 13	9 to 12	11 to 12
Mean annual precipitation	6.77″	8.43″	6.65″	14.33″
Precipitation—July, August and September	1.05″	1.05″	0.81″	1.61″
Mean annual temperature	52.4°	49.8°	50.8°	47.9°
Maximum annual temperature	106.°	103.°	102.°	97.°
Minimum annual temperature	—2.°	—6.°	—2.°	—2.°
Last killing frost in spring	Apr. 22	May 20	May 7	May 1
First killing frost in autumn	Oct. 12	Sept. 19	Oct. 7	Oct. 22
Length of frost free period (days)	173	122	153	174

(a) The above records are to 1910, inclusive, the compilation for 1911 not yet having been issued by the Weather Bureau.

(b) This column is made up from the records for Trinidad and Ephrata, a slightly greater weight being given to the latter station.

(c) Observations for the various phenomena were not begun simultaneously at any station, hence the two figures for length of record.

From the above tabulation it is apparent that Quincy Valley has certain climatic advantages over the Yakima, Sunnyside and Wenatchee districts, its salient features being that its weather is somewhat warmer and that, excepting Wenatchee, its frost free period is appreciably longer, which factor is important in its relation to fruit culture for it approximately measures the growing season for crops. It is true that two of these districts show a slightly greater annual precipitation than does Quincy Valley, but it will be noted that the summer precipitation in the Quincy Valley is surpassed only by that of Wenatchee. The record as a whole shows up exceptionally well for the Quincy Valley country.

CROPS.

At the present time, on account of the deficient rainfall and because no water is available for irrigation, practically the only crops attempted to be grown are hay and grain, and thus far these have scarcely maintained the rancher. Exceptions to the above are occasional small tracts where irrigation by pumping or from springs has been successfully applied to fruit raising, as for instance the Keigly 25-acre tract at Quincy, the Tolliver 20-acre tract at Ephrata and notably the Techacek orchard tract on the shores of Moses Lake. From the results obtained on these tracts and from the climatic conditions as disclosed in the records hereinbefore quoted, there can be no doubt that this valley will successfully grow all the fruits grown in the Wenatchee and Yakima valleys. That all forage crops such as timothy, alfalfa, wheat, oats, rye, etc., will flourish here when water is available has been abundantly proven. It goes without saying that a certain area will always be devoted to these forage crops, but on account of the great adaptability of the valley to fruit and vegetable culture and because of the high values of land attainable under such culture, it is believed that when irrigation water is provided at least the major portion of the lands will be devoted to this class of farming. As an evidence of the value of the soil in producing fruits and vegetables, it may be stated that Quincy Valley has already won several first prizes for this class of culture, not only at the successive annual competitions of the Spokane Interstate Fair, which embraces the states of Idaho, Oregon and Washington, but also at the Alaska-Yukon-Pacific Exposition of 1909, which was international in its scope.

TRANSPORTATION.

The transportation facilities of Quincy Valley are good. As will be noted on the index map the Great Northern Railway traverses the entire north boundary of the tract, the Chicago, Milwaukee & Puget Sound Railway the south boundary, the Connell Northern branch of the Northern Pacific Railway lies just east of its eastern boundary and the Columbia River forms

its western boundary. In addition to the above the Chicago, Milwaukee & Puget Sound Railway has about ready for operation a branch from its main line to Moses Lake and the Northern Pacific cut-off from Ritzville to Ellensburg has partially been constructed and this line traverses the very heart of Quincy Valley. Furthermore the open and level character of the country lends itself to cheap highway construction so that on full development of the project the remotest ranch would need be scarcely more than a two or three hour drive from a railroad.

LAND OWNERSHIP.

Practically the entire project is included within the land grant limits of the Northern Pacific Railway, a land grant by which the railway received from the government title to every odd-section of land. It appears that, excepting a few sections bordering on Moses Lake, the railway company has disposed of these lands to individuals, title however remaining in the name of the company until all payments on the purchase contract have been satisfied. Counting such lands, however, as in private ownership, the character of land ownership of the entire irrigable area is approximately as follows:

Government land	6%
Private land	85%
State land	7%
Railroad land	2%
Total	100%

DUTY OF WATER.

Experience with existing irrigation practice in central Washington, as indicated both by crop experiments and by the amount of water guaranteed in the water-right contracts of various irrigation companies, shows the water requirements for different crops to be about as stated below, the amounts given being the vertical depth of water delivered to the land during the irrigation season:

Alfalfa and forage crops in general	32" to 36"
Vegetables	30"
Fruits	24"

With more careful cultivation of the soil and with a general improvement in irrigation methods the tendency is and will continue to be to decrease the amount of water applied to the land, so the above figures may be assumed to be at least a conservative maximum of what would be required for this project. It may be assumed that all the lands will not be devoted to fruit culture and I have therefore assumed as a basis for all my preliminary estimates an average duty of 30″ of water delivered to the land. In the distribution system, the laterals being unlined, I have assumed a loss of 16 2-3%, thus making the requirement at the head of the distribution system, i e., at the lower end of the main canal, 36″.

The seepage and evaporation losses from the main canal will depend upon its total length and upon the relative lengths of lined and unlined portions, none of which can definitely be determined until final surveys are made. The major portion of the main canal, however, we know will need to be lined and I have therefore assumed its seepage losses at 15%, thus making the resultant diversion duty of water 42″ at the intake of the main canal.

IRRIGATION SEASON.

The irrigation season should extend from April 1st to October 31st, and the distribution throughout the season would be about as follows:

During April	7% of total supply.
During May	15% of total supply.
During June	17% of total supply.
During July	29% of total supply.
During Aug.	20% of total supply.
During Sept.	15% of total supply.
During Oct.	7% of total supply.
Total	100%

The maximum draft, i. e., the requirement for the month of August, will of course determine the necessary capacity of the main canal.

WATER RIGHTS.

Before proceeding with a description of the water supply, which as already stated would be from Wenatchee Lake and Wenatchee River, brief reference should be made to existing water rights.

The only water rights which at the present time have any bearing on the project are those for existing irrigation systems in Wenatchee Valley and for the few power plants at and above the town of Wenatchee.

The Great Northern Railway Company's Tumwater Power Plant, located about three miles above Leavenworth on Wenatchee River, claims a water right of 525 second-feet and has an installation practically sufficient to utilize that amount of water. As the main canal diversion for the Quincy Valley Project must be well above the intake for this power plant, the storage operations of the scheme must be such as not to affect the normal discharge of the river when the same falls below 525 second-feet at the power penstock intake. There are other power plants on Wenatchee River, but as the Tumwater plant above described is highest up on the river and requires the largest flow of water for its operation, any provision made for it would more than provide for the smaller plants below.

The present area under irrigation in Wenatchee Valley does not exceed 20,000 acres and with possible future development of existing canals either by gravity extensions or by pumping, the gross irrigable area will probably not exceed 25,000 acres. This acreage would require less water than that demanded by the Tumwater Power Plant and as the latter is above practically all present diversions for irrigation its requirements would remain the criterion as affecting storage operations of the Quincy Valley Project.

WATER SUPPLY.

Wenatchee River, including its tributary, Chiwawa Creek, has a drainage area of 560 square miles above the proposed reservoir dam site hereinafter described. It drains the eastern slope of the Cascade Range, reaching an altitude of 8,100 feet at the

head of White River, the mean altitude for the entire basin being about 5,000 feet. Its drainage area is all mountainous and fairly well forested with fir, pine and cedar and it is in fact included within the Wenatchee National Forest. There is practically perpetual snow on the highest peaks along the western rim of the basin and over the entire water shed a heavy annual precipitation prevails.

The water supply records available at the time my initial report on this project was prepared was for a single station (Cashmere) and covered only a period from July, 1904, to December, 1906, inclusive, the data subsequent to that date having been withheld by the United States Geological Survey pending additional observations to establish the accuracy of the original records. At the present time, however, we have available actual published records of the United States Geological Survey up to and including the year 1909 and the unpublished provisional data for the years 1910 and 1911.

Realizing the importance of having a gaging station near the proposed reservoir dam site, the Quincy Valley Water Users' Association established in December, 1910, such a station at a convenient point about three miles below the said dam site, which station has been and is now regularly observed and records of the same maintained by the United States Geological Survey, in co-operation with the State Geological Survey.

The data for these two stations, namely the one at Cashmere and the one recently established and designated as being near [illegible] are submitted herewith in complete tabular form and a comparison is made with previously published records. It will be noted that the government has revised its original figures, the records now indicating a greatly increased discharge of [illegible] River. This increase in Wenatchee River run-off [illegible] an additional increase in the area that has to be irrigated [illegible].

TABLE C. DISCHARGE OF WENATCHEE RIVER AT CASHMERE, DRAINAGE AREA, 1,250 SQUARE MILES.

Month Year	January	February	March	April	May	June	July	August	September	October	November	December	For Year or Prior
1904							(a) 4,260 3,180 3,780 37,500	3,180 1,280 2,080 128,000	1,480 880 1,080 64,300	1,280 730 855 52,600	1,940 690 1,100 65,500	1,590 1,090 1,300 79,900	428,000
1905	1,100 780 900 55,300	1,700 650 990 55,000	6,040 1,920 4,370 269,000	11,400 2,210 4,710 280,000	11,600 4,740 6,550 408,000	14,900 6,900 10,500 625,000	7,200 2,500 4,450 274,000	2,350 1,080 1,560 96,900	1,820 880 1,090 64,900	8,760 1,190 2,950 81,000	1,940 1,190 1,400 83,300	1,280 780 965 59,300	14,900 650 3,380 2,450,000
1906	1,700 780 1,040 64,000	1,940 1,190 1,520 84,400	3,180 1,190 1,450 89,200	9,980 3,000 5,860 349,000	11,600 4,740 7,860 483,000	8,760 3,800 5,890 321,000	6,320 1,590 3,260 200,000	1,480 880 1,160 71,300	1,700 830 1,000 59,500	12,400 830 2,420 49,000	19,200 (b) 1,940 4,070 113,000	1,480 (c) 1,380 1,420 141,000	2,000,000
1907	1,380 880 1,040 64,000	4,260 960 2,420 134,000	2,680 1,280 2,040 125,000	7,500 1,820 4,670 278,000	18,500 6,320 12,500 769,000	19,000 5,500 9,500 565,000	6,600 2,500 4,320 266,000	2,660 1,110 1,650 95,900	1,700 890 1,220 72,600	1,110 1,110 1,110 68,200	2,500 1,120 1,300 77,400	2,350 1,190 1,730 106,000	19,000 890 3,620 2,620,000
1908	1,700 960 1,390 85,500	1,480 860 1,210 69,600	3,580 1,380 2,380 146,000	8,760 2,070 4,560 271,000	9,780 5,760 8,050 495,000	6,320 11,500 684,000	13,200 3,800 9,590 590,000	3,900 2,060 127,000					2,470,000
1909				5,500 (d) 4,380 4,970 49,300	11,600 4,380 7,420 456,000	21,400 7,800 13,600 809,000	9,440 2,660 5,510 339,000	1,940 1,080 1,510 92,800	1,380 730 980 55,300	1,480 940 1,090 67,000	20,800 1,040 5,240 312,000	17,100 1,640 4,080 248,000	2,430,000
1910	2,680 1,210 1,590 97,800	1,600 1,070 1,390 77,200	10,580 1,600 4,550 280,000	20,500 2,580 7,270 433,000	20,000 7,920 13,100 806,000	12,200 5,080 7,700 458,000	6,680 2,580 4,710 290,000	2,490 940 1,680 103,000	1,020 725 873 51,900	4,840 750 2,870 76,000	13,200 1,800 4,100 244,000	2,940 1,320 1,750 108,000	20,500 725 4,320 3,120,000
1911 (e)	1,620 940 1,250 76,980	1,110 780 934 51,980	3,290 780 1,600 98,400	6,710 2,020 3,620 215,600	11,700 4,130 6,160 379,680	19,300 5,150 10,700 687,000	5,740 2,020 3,800 234,000	2,020 940 1,290 79,300	1,940 800 1,110 66,000	775 620 682 41,980	6,560 620 1,900 113,000	1,800 940 1,340 82,400	19,300 620 2,870 2,074,800

TABLE C. DISCHARGE OF WENATCHEE RIVER AT CASHMERE, DRAINAGE AREA, 1,250 SQUARE MILES.—Concluded.

Month Year	January	February	March	April	May	June	July	August	September	October	November	December	For Year or Prior
For Period	2,660 730 1,200 73,900	4,260 650 1,420 78,700	10,500 780 2,730 167,900	20,500 1,920 5,100 303,700	20,000 4,130 8,810 481,600	21,400 3,800 9,850 585,600	13,200 1,590 5,060 311,400	3,800 890 1,610 99,200	1,940 725 1,040 62,100	12,400 620 1,710 105,100	20,800 620 2,420 144,000	17,100 780 1,910 117,800	21,400 620 3,580 2,591,000

(e) DISCHARGE OF WENATCHEE RIVER NEAR LEAVENWORTH, DRAINAGE AREA, 590 SQUARE MILES.

1910												1,780 910 1,130 69,600	69,600
1911	1,060 710 841 51,800	750 490 625 34,700	1,820 490 891 54,800	3,910 1,600 2,220 132,000	6,130 3,130 3,950 243,000	8,250 3,480 5,470 326,000	3,620 1,710 2,740 168,000	1,600 920 1,150 70,700	1,390 670 957 56,900	670 520 582 35,800	4,060 520 1,430 85,100	1,540 830 1,090 67,000	8,250 490 1,330 1,325,900

These data are deduced from the published records (to 1909 inclusive) and the unpublished records (1910-1911) of the United States Geological Survey under whose direction the gagings are maintained. The first three lines for each year indicate respectively, maximum, minimum and mean discharge in second feet; and the last line indicates the run-off in acre feet for the month, year or period as the case may be. (a) For period July 27-31; (b) Nov. 1-14; (c) Dec. 27-31; (d) Apr. 26-30; (e) This record is for Dryden Station, located a short distance above Cashmere Station, which it is intended to replace, the latter station having been abandoned in September, 1911. (f) This gaging station located in Section 12, T. 26 N., R. 17 E., W. M., being about three miles below the upper dam site of proposed Wenatchee Lake Reservoir.

From the above table it will be noted that for the year 1911 the discharge at the upper gaging station, with a drainage area of 590 square miles, is about 64% of that for the Cashmere gaging station with a drainage area of 1,250 square miles. Assuming that this same ratio would hold for mean years and that the discharge at the reservoir dam site, including the discharge of Chiwawa Creek which it is proposed to divert into the reservoir, would be slightly less than that at the upper gaging station, I have deduced the following as the actual or the estimated mean annual run-offs at those critical points which must be considered in determining the area that can be irrigated on the basis of the water supply, and the amount of storage required therefor:

At Cashmere, 1,250 square miles (record).....2,600,000 acre-feet
At Great Northern Power Dam, 700 square miles (estimated) .....1,920,000 acre feet
At Diversion Site hereinafter described, 280 square miles (estimated) .....1,880,000 acre-feet
At Reservoir Dam Site, including Chiwawa Creek, 560 square miles (estimated) .....1,640,000 acre-feet

After making allowance for evaporation losses from the proposed reservoir hereinafter described (22,500 acre-feet) and for a continuous flow of 525 second-feet, to satisfy the requirements of the Great Northern Railway Power Plant, which latter would also satisfy all present power and irrigation rights in Wenatchee Valley, I estimate that there will be available for irrigation in mean years about 1,520,000 acre-feet of water, or an amount sufficient to irrigate 435,000 acres, assuming, as hereinbefore set forth, a diversion duty of 42″ and a delivery duty of 30″.

It may be noted here that if a delivery duty to the land of 27″ instead of 30″ be assumed there would be sufficient water to irrigate 475,000 acres. In this connection I would state that the area actually to be irrigated can be determined only by a careful examination of the entire body of land, classifying it section by section as irrigable or non-irrigable, and such a survey has not as yet been made.

STORAGE.

It will be noted in the tabulation of run-off previously quoted, that even at Cashmere which is far below the point where our diversion must be made, the normal discharge of Wenatchee River is not sufficient for a project of the size contemplated and it is therefore essential to secure the maximum storage possible.

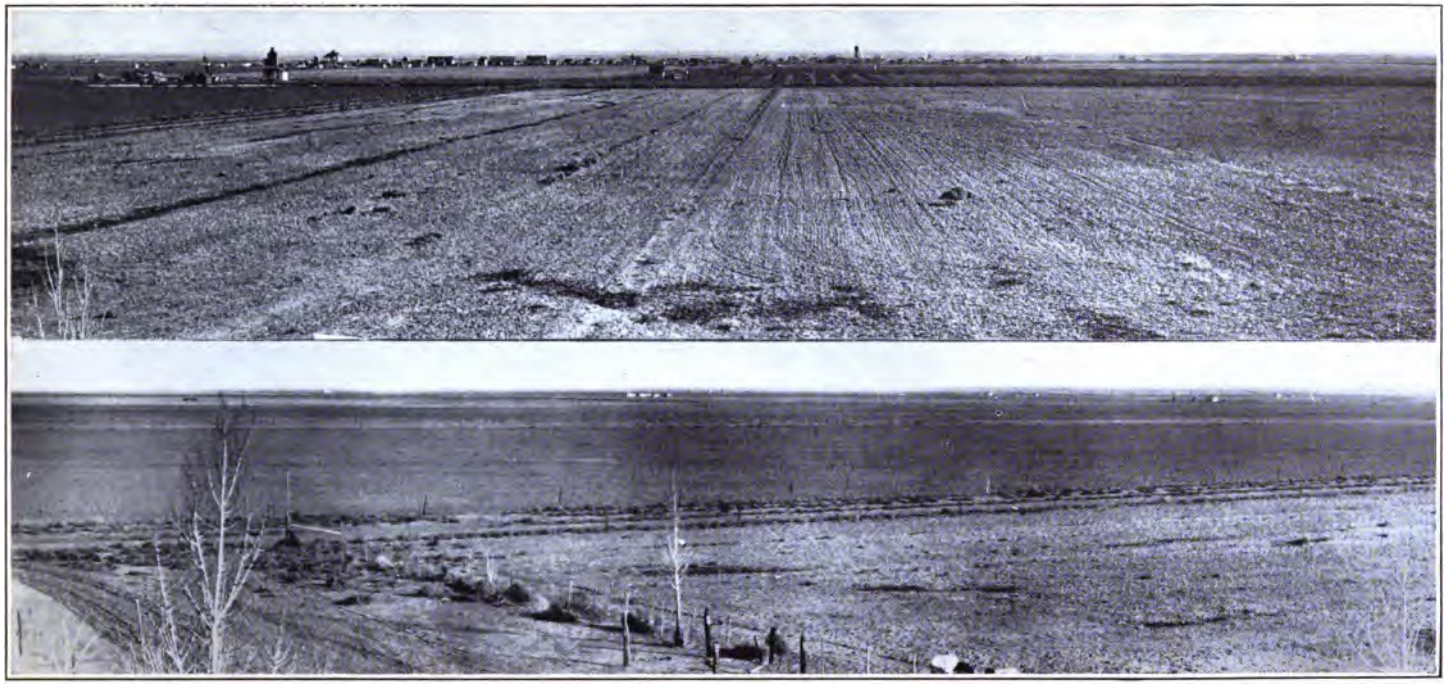
I estimate that the normal storage requirement, i. e., in years of mean run-off, will be about 637,000 acre-feet, but to provide for years of minimum run-off, taken as 60% of mean run-off, the approximate maximum storage requirement is 1,142,000 acre-feet for an irrigated area of 435,000 acres.

WENATCHEE RESERVOIR.

Wenatchee Lake, at an altitude of 1,870 feet and with an area at mean stage of about 2,400 acres, affords a very favorable reservoir site. It is sufficiently high to command the lands to be irrigated and is located on the best part of the Wenatchee River drainage (See Plate II). At its outlet its width narrows to form the regular channel of the river and this point affords a fair site for a low dam, but a low dam would not provide the storage required and a high dam at this point, on account of its great length, would be impracticable.

A far more favorable site for a high dam is found in sections 26 and 35, Tp. 27 N., R. 17 E., which site has the important advantages of increasing the size of the reservoir and of including the Nason Creek drainage of 121 square miles.

Other possible dam sites exist further down the canyon, surveys of which have not yet been made, but before any final decision is reached as to the best location for a dam the entire canyon must be carefully examined and all possible sites accurately surveyed. A favorable site below the mouth of Chiwawa Creek for instance would involve but little increase in height of dam and would at the same time avoid the artificial diversion of that stream into the reservoir as will be necessary if the upper site is adopted.



For the present and until definite surveys and studies of this lower dam site are available, all estimates are made on the basis of the adoption of the upper dam site.

It is proposed to build here an earthern dam to an elevation of 2,000 feet above mean sea level, being a maximum height of 146 feet above the stream bed. The top length of this dam will be 4,446 feet and with upstream and downstream slopes of 3 to 1 and 2 to 1 respectively, and with a top width of 20 feet, it will have an earth volume of 4,600,000 cubic yards. It is proposed to protect both faces of the dam with riprap 18″ thick and it is also planned to carry two lines of concrete cut-off walls extending the entire length of the dam, these walls to go down and into the bed rock and project about 5 feet into the main body of the dam. It is proposed also to construct a concrete lined spillway of 25,000 second-feet capacity around the southerly end of the dam.

SURVEY OF RESERVOIR.

Pending an actual survey of the reservoir site and recognizing its strategic relation to any general scheme of irrigation in central Washington, the government withdrew from public entry all lands within the Wenatchee reservoir site, the President of the United States having issued such order through the Secretary of the Interior under date of January 17, 1911. This order withdrew from entry 18,553 acres, embracing lands both within and without the reservoir site, reserving the same for use in connection with irrigation only.

During the summer of 1911, the Quincy Valley Water Users' Association made, under my direction, a complete survey of the Wenatchee Lake reservoir and dam site and I am permitted by that organization to give in Table D complete data as to the areas and the capacities of this reservoir for varying heights of storage.

TABLE D. WENATCHEE LAKE RESERVOIR.
(From Surveys Completed September, 1911.)

CONTOUR ELEVATION.	Area. Acres.	Capacity between contours. Acre-feet.	Capacity to any contour. Acre-feet.
1,855 feet	0		0
		115	
1,860 feet	46		115
		36,320	
1,880 feet	3,698		36,435
		94,510	
1,900 feet	5,865		130,945
		134,750	
1,920 feet	7,610		265,695
		176,290	
1,940 feet	10,019		441,985
		213,430	
1,960 feet	11,324		655,415
		239,420	
1,980 feet	12,618		894,835
		63,335	
1,985 feet	12,715		958,170

REMARKS.—Elevation of river bed at dam site, 1,854 feet. Proposed top of dam elevation, 2,000 feet. Proposed spillway elevation, 1,985 feet. Proposed spillway capacity, 25,000 second-feet. Maximum water surface elevation in flood, 1,995 feet.

As will be noted from Table D the survey indicates a storage capacity of about 960,000 acre-feet to the proposed flow-line of the reservoir at an elevation of 1,985 feet, this being the elevation assumed for the crest of the spillway with height of dam at an elevation of 2,000 feet. Although this storage capacity is somewhat less than the apparent maximum storage requirement, under extreme conditions, as hereinbefore set forth, yet it is believed that it will prove sufficient, or at least that greater storage need not be provided at this time and for the following reasons, to-wit:

(a) It will take at least 15 years after water is delivered to settle up the entire irrigable area, by which time improved irrigation methods may materially improve the water duty, and furthermore the general rise of the ground water plane may tend to sub-irrigate some of the low lying lands.

(b) The increased length of discharge record may make a better showing for low and mean years than is indicated by the record now available and furthermore the lowest year now of record is 25% in excess of the minimum assumed in estimating possible maximum storage requirements.

(c) Maximum storage will not be required until the entire area is under irrigation, at which time the character of the crops grown and the exact irrigation requirements will be definitely known, when additional storage if needed can be more intelligently and economically provided.

CHIWAWA CREEK.

This creek has an excellent water shed of 164 square miles, extending westward to the summit of the Cascades, and it is one of the important feeders of Wenatchee River. Unfortunately it empties into the river below the dam site as now proposed, but to secure the great amount of storage required for this project, it must in some manner be included in the storage system. This can easily be accomplished by means of a feed canal not exceeding two miles in length extending from Chiwawa Creek to Fish Lake (see Plate II), thus making it in fact a part of the main reservoir. This canal could be unlined and would need to have a capacity of about 2,000 second-feet. There will also be required a low diverting dam on Chiwawa Creek, but the total cost of delivering this supply into the reservoir would be relatively small and should undoubtedly be done unless subsequent surveys prove that a storage reservior on Chiwawa Creek itself would be more economical, which however in my opinion is very doubtful.

OTHER SOURCES OF WATER SUPPLY.

Should the Wenatchee water supply prove insufficient for the area it is finally desired to irrigate, or in the event that it is desired to expand the project at some future date, other possible sources of water supply might be found in Entiat, Icicle and Peshastin creeks. They are at least worthy of consideration in this connection and continuous discharge records on these streams would be extremely valuable.

Some study has already been given to the Entiat possibility and the indications are that on account of the complicated water rights on this stream and the high cost of its diversion into the Wenatchee drainage basin its use would probably prove impracticable, but no such study has yet been given to the other two streams named.

POINT OF DIVERSION.

To irrigate an area of 435,000 acres there will be required a maximum canal capacity of nearly 5,000 second-feet. For a main canal length of 65 miles, and the gradients required for the varying types of conduit which will need to be employed, it is estimated that a total head of about 260 feet will be consumed. With a main canal elevation of 1,340 feet at Quincy this means that the canal must be diverted from the river at an elevation of 1,600 feet and it is found that this will be approximately where Fall Creek empties into Wenatchee River, about 12 miles below the proposed reservoir dam site. At this point a low overflow weir and head-works would need to be constructed to serve the purpose of diverting Wenatchee River into the main canal. It is proposed to release the water from Wenatchee Lake reservoir, as required, by means of an outlet tunnel which would drain the reservoir to contour elevation of 1,855 feet. This water would be turned directly into the natural channel of Wenatchee River, or it would be possible to utilize it for power purposes by carrying it in a power canal on low gradients to a point just above the proposed diversion dam site where a power house could be located. It is not known that such power development would prove economical or desirable and it is simply mentioned here as a possibility.

MAIN CANAL.

As has already been stated the capacity of the main canal will need to be about 5,000 second-feet at the intake and about 4,250 second-feet at its lower end for the acreage contemplated, and for the gradients now estimated it would have a length of 65 miles. It will be appreciated, of course, in dealing with canals of this magnitude that only the most careful surveys and most considerate study can determine the economic gradients and economic routes and, at least at the upper end of the canal, alternative routes are possible.

If the canal were diverted from Wenatchee River at the mouth of Fall Creek, instead of following Tumwater Canyon on the steep mountain side above the Great Northern Railway track, it

could leave the Wenatchee by means of a three-mile tunnel, thereby bringing it into Freund Creek Canyon. From this canyon it would follow Chumstick Valley to the north side of Wenatchee Valley which it would parallel for a distance of 31 miles, or to Columbia River. The water would be conveyed under Columbia River by means of a pressure tunnel, and the canal would continue in a southeasterly direction along a line approximately paralleling the Columbia River and distant from one to three miles therefrom, a length of 21 miles to Moses Coulee; thence easterly from Moses Coulee and away from the Columbia River a distance of 12 miles to the end of the main canal, this point being about one mile north of the town of Quincy.

The route of the main canal throughout the major portion of its length is over hilly and mountainous country, involving much rock work and heavy construction in general. On account of the rough topography and the several canyons and rivers to be crossed, all types of conduits will need to be employed, namely lined and unlined open canal, side hill flumes, inverted siphons, grade tunnels, and one pressure tunnel under Columbia River. Probably not to exceed 5 or 6 miles of unlined canal can be economically employed in its entire length and this at the extreme lower end of the canal.

I thus purposely call attention to the magnitude of this main canal construction, not as a discouraging prospect, for I have abundant faith in the feasibility of the project, but because I desire not to minimize the actual difficulties which I know will be encountered and which must be solved.

Among the more important siphons required other than the Columbia River crossing, which is separately considered, may be mentioned the crossings of Chumstick Creek, Derby Canyon and Olalla Canyon westerly from Columbia River, and Rock Island Creek, Moses Coulee and Willow Springs Canyon easterly from Columbia River.

COLUMBIA RIVER CROSSING.

This proves to be one of the formidable features involved in utilizing the Wenatchee River water supply, for the bed of

Columbia River, at an elevation of about 600 feet above sea, is nearly 900 feet below the proposed hydraulic gradient of the canal line. It will therefore require the construction of a bridge to support an inverted siphon with a maximum head of about 800 feet, or a pressure tunnel under the river bed with a maximum head of about 1,000 feet. The proposed crossing is at a point about three miles north of Wenatchee, and its estimated length, including inclined approaches to the river crossing proper, is about 10,000 feet. It being necessary to conserve as much head as possible and because of the heavy friction losses involved in conducting the water in a series of small pipes, it is believed most economic to restrict the conduit to one, or at most two pipes. For a single pipe 22 feet is found to be the economic diameter, and for two pipes 16 feet each, and of these alternatives the single pipe is the less expensive and was therefore adopted in arriving at the preliminary estimates of the cost of the project.

To utilize a bridge for the support of a siphon at this crossing, it would be necessary to provide a clearance above high water sufficient to accommodate all present and prospective steamboat traffic. This would mean the construction of high piers at great cost, and the superstructure, with an imposed load at least five times that put upon our heaviest modern single track railroad bridge, would be unduly expensive, all of which would be in addition to the cost of the siphon proper.

A pressure tunnel below the river bed would not only be safer construction, but present estimates indicate that it would also be far more economic construction. I have assumed a depth of 100 feet below the river bed for this pressure tunnel, but its proper position can be determined only by careful surveys and extensive borings, which of course have not yet been made.

The type of construction contemplated is an outer shell of concrete not less than 18″ thick and properly reinforced to resist internal and external pressure, and an inner shell of steel 1″ thick to insure water tightness and also to resist internal pressure. The thickness of concrete used and the amount of rein-

forcement required will of course depend upon the character of rock formation encountered.

Such a pressure tunnel would not be an unusual type of construction, as is indicated by the Hudson River pressure tunnel forming a part of the New York Aqueduct which is now under construction. This tunnel will have an internal diameter of 14 feet and will be under a maximum head of 1,500 feet.

WASTEWAYS.

To properly regulate the canal and to afford protection, should rapid unwatering of the canal be required, probably not less than three wasteways will need to be provided; one just below the head works, one at Columbia River crossing, and one near the end of the main canal.

DISTRIBUTION SYSTEM.

This will consist of one main lateral extending south from Quincy and one extending as a continuation of the main canal from Quincy to a point north of and opposite Ephrata, with a final waste channel therefrom draining into Moses Lake. The land south of Frenchman Hills would be reached by extending one of the main laterals, in a tunnel through the low divide in the Frenchman Hills, or by an open canal around either end of the Hills as future surveys may prove to be most economical. In addition to the main laterals there will be required a sub-lateral system together with patrol houses and a telephone system for the proper operation of the canal.

Since the body of irrigable lands are generally located very favorably for irrigation, it is not believed the distribution system will prove unusually expensive. The cost should not exceed from $5 to $10 per acre, depending upon the area of farm unit to which the sub-laterals are constructed.

COST OF PROJECT.

In the absence of actual surveys for the major part of the work involved in this project one approaches the matter of final cost with some reluctance. Yet it is recognized that such pre-

liminary estimates are necessary as a basis for future stu and to point out the advisability of making more detailed vestigations.

Based therefore upon the reconnaissance work that has ready been done and upon the important data thus far sembled, I would say that I have arrived at a preliminary timate of approximately $100 per acre for a project of 435,0 acres, which estimate I regard as conservatively high. T gross figures entering into this estimate are as follows:

Chiwawa Diversion	$85,000
Storage (960,000 acre-feet)	2,370,000
Main diversion dam and headworks	150,000
Main canal, exclusive of Columbiar River crossing (63 miles)	24,948,000
Wasteways	200,000
Columbia River Crossing	5,500,000
Distribution System	3,263,000
Rights of Way other than reservoir	50,000
	$36,416,000
Engineering and contingencies, 20%	7,283,000
Total	$43,699,000

FUTURE WORK.

There is yet much work to be done before a final estimate o the cost of this project can be determined. Among other thing there will be required an actual survey of the canal line, a lan classification of the irrigable area, a detailed study of the dis tribution system, surveys and borings of the Columbia Rive crossing and additional dam surveys in Wenatchee Canyon.

LAND VALUES.

Granting that the project is physically feasible, as I fully believe it is, there yet remains the important consideration as to whether the final values attainable by the lands to be irrigated will justify the expense of bringing the water to them.

The probable range of land values that will obtain on this project are best illustrated by the actual land values at the present time in the Yakima and Wenatchee districts. The sale of developed orchards in these districts at $2,000 per acre is so

frequent as to no longer excite comment and I would hesitate to place the average price at which such orchards could be purchased at less than $1,000 per acre. By a developed orchard is meant one having healthy trees of approved varieties, eight years old or more, and having of course an ample water right. For good lands under a canal with ample water right, but as yet unplanted to orchard, it is difficult to find a desirable tract for less than $300 per acre.

The above should be a fair criterion of what the Quincy Valley lands will bring. With an assured water supply and considering the exceptionally favorable features of the project, namely, its climate, the fertility of its soil and its excellent transportation facilities, I believe it conservative to assume that these lands unimproved but with a water right will be worth $300 per acre, and this value would of course more than justify the estimated cost of irrigation.

CONCLUSION.

Before closing I would call attention to the great need of opening up new agricultural areas on this western coast to meet the land demand that is certain to ensue upon the completion of the Panama Canal. The consummation of that enterprise, it is conceded by every thoughtful writer on the subject, is bound to bring the Pacific Coast an unprecedented immigration from European countries and efforts should be made to prepare for that situation.

There are a number of large irrigation projects awaiting development, not only in Washington, but in other states as well, projects which will ultimately cost from $15,000,000 to $50,000,000 each and if this western country is to achieve its full development it must find some means of undertaking these larger schemes when engineering investigations prove them to be feasible and practical. If they prove too large or for other reasons fail to attract private enterprise, then it is my confident belief that at some early day a definite effort must and will be made to secure such legislation as will make possible their construction through the guarantee of state or federal aid, or perhaps by means of both these agencies.

WASHINGTON GEOLOGICAL SURVEY

HENRY LANDES, State Geologist

BULLETIN No. 15

A Preliminary Report on the Tertiary Paleontology

OF

Western Washington

By CHARLES E. WEAVER

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LETTER OF TRANSMITTAL.

Governor M. E. Hay, Chairman, and Members of the Board of Geological Survey:

GENTLEMEN—I have the honor to submit herewith a report entitled "A Preliminary Report on the Tertiary Paleontology of Western Washington," by Charles E. Weaver, with the recommendation that it be printed as Bulletin No. 15 of the Survey reports.

Very respectfully,

HENRY LANDES,
State Geologist.

University Station, Seattle, August 1, 1912.

CONTENTS.

Description of Species—*Continued.*

A PRELIMINARY REPORT ON THE TERTIARY PALEONTOLOGY OF WESTERN WASHINGTON.

INTRODUCTION.

The purpose of this paper is to record as briefly as possible the purely scientific facts concerning the Tertiary Palaeontology of Western Washington. A short account is given of the character and distribution of the several divisions of the Tertiary and their faunas. A northwestern Tertiary province is recognized and an attempt is made to interpret its history from the close of the Cretaceous to the present time. A total Tertiary invertebrate marine fauna of two hundred and forty-six species has been discovered. Eighty-four of these are new and are described and figured for the first time. This report is preliminary to a more detailed one, which will appear later accompanied by maps and a discussion of the economic geology in relation to the occurrence of oil.

The field work upon which this report is based has been carried on by the writer at intervals during the past five years. During the summer of 1911 four months were spent in the field studying and mapping the areal geology of southwestern Washington and a strip along the coast from Gray's Harbor northward to Cape Flattery and thence along the north side of the Olympic Peninsula to Port Angeles. Previous to that year a study had been made of all the bed rock outcrops occurring in the Puget Sound Basin and the Quimper Peninsula. During the summer of 1911 the writer was assisted in this work by Messrs. Charles R. Fettke, Donald Ross, T. A. Bonser and Olaf Stromme. The specific determinations of the fossils were made by the writer in the Palaeontology laboratory of the University of California. The types of the new species described in this report are in the Palaeontological collections of the Uni-

versity of Washington. ' The writer wishes to express his acknowledgements to all who have aided in this work and especially to Professor John C. Merriam and Mr. Bruce Clark of the Palaeontology Department of the University of California, who kindly placed at his disposal their collections and library facilities.

STRATIGRAPHY.

GENERAL STATEMENT.

The Tertiary formations of western Washington are composed of non-metamorphosed sedimentary and igneous rocks which rest unconformably upon an older complex series of igneous and metamorphic rocks. The Tertiary sedimentary formations comprise materials deposited in lake basins, brackish water estuaries and marine basins. Those of lacustrine origin are confined almost entirely to eastern Washington and the eastern portion of the Cascade Mountains. The deposits in the western foothills of the Cascades are for the larger part of estuarine origin, while those in southwestern Washington and the Puget Sound Basin are mostly marine. The total maximum thickness of the Tertiary formations in western Washington is over thirty-four thousand feet. This thickness, however, is not represented in any one continuous section. The strata are for the most part involved in a complex series of folds. In southwestern Washington the entire structure can be referred to two exceedingly complex westerly pitching geosynclines.

PRE-TERTIARY BED ROCK COMPLEX.

In every locality where the contact between the Tertiary and older formations may be observed there is a marked unconformity. These older rocks compose the entire central core of the Olympic Peninsula, the San Juan Islands and the bulk of the northern portion of the Cascade Mountains. In the southern portion of the Cascades the older rocks pass beneath a thick covering of Tertiary lavas. They do not occur in southwestern Washington, but seem to pass down below sea level from the

southern foothills of the Olympic Mountains until they again reappear in the northern foothills of the Klamath Mountains of southern Oregon. Isolated occurrences, however, may occur in the northern coast ranges of Oregon. The older rocks represent a series of sandstones, shales, limestones, conglomerates, interbedded volcanic tuffs and lavas which have been extensively metamorphosed, largely as the result of numerous intrusions of acidic and basic magmas. The intrusions of igneous magmas seem to have occurred at or near the close of the Jurassic.

The metamorphic rocks belong largely to the Carboniferous, Triassic and Jurassic, and bear a very striking resemblance to the Franciscan formation of California and southern Oregon.

On the northern shore of Vancouver Island and on the northern fringe of the San Juan Islands the Upper Cretaceous occurs resting unconformably upon the older metamorphic complex. These rocks are not metamorphosed. The Lower Cretaceous is absent. No deposits of Cretaceous age are definitely known to exist in any other part of western Washington, although they may lie deeply buried beneath the later Tertiary formations.

TERTIARY FORMATIONS.

The following subdivisions have been made of the Tertiary formations in western Washington:

Pleistocene—

Pliocene—wanting.

Miocene
- Upper — Montesano formation.
- Lower
  - Chehalis formation.
  - Wahkiakum formation.
  - Blakeley formation.

Oligocene — Lincoln formation.

Eocene
- Upper
  - Tejon formation — Puget / Brackish water group
  - Cowlitz formation — Puget / Brackish water group
- Lower—wanting.

EOCENE.

GENERAL STATEMENT.

The Eocene of western Washington consists of two divisions, an older which is provisionally termed the Cowlitz formation, and a later one which is distinctly Tejon. Both belong to the Upper Eocene. The rocks composing these formations are sandstones, shales, conglomerates and subordinate amounts of shaly limestone, together with numerous intercalated layers of tuff and basaltic lava. The sediments are partly of marine and partly of brackish water origin. The former prevail in the western part of the area examined and the latter to the east, on the western slopes of the Cascades. Eocene strata form the surface outcrops over an area of about 4,000 square miles. This area would be much larger if the thick veneer of glacial drift in the Puget Sound Basin were to be stripped off.

The formations outcropping in the Cowlitz Valley from the Columbia River northward into Thurston County are Eocene. They are partly marine and partly brackish water deposits. In western Lewis, Cowlitz, Wahkiakum, eastern Pacific, Chehalis and western Thurston counties, the marine sediments prevail. To the east they thin out and are replaced by brackish water and occasionally fresh water materials. West of the Cowlitz River marine sediments prevail. In Pierce and King counties they attain a thickness of over eight thousand feet. They have been described as the Puget Group* which is the coal bearing horizon of western Washington. The Puget formation is composed exclusively of brackish water sediments together with interbedded lava flows. It extends eastward into the Cascade Mountains and passes unconformably beneath later Miocene and Pliocene lava flows. The first Eocene deposits to reappear on the eastern margin of these later Tertiary lavas are a part of the Roslyn formation which is coal bearing and belongs to the upper portion of the Eocene. These deposits are regarded as lacustrine in origin. The maximum thickness of the Eocene is at least ten thousand feet. In the type sections

*Tacoma Folio No. 54, U. S. Geological Survey.

where detailed stratigraphic sections have been made, the base of the series has not been reached. In Pierce County the Puget group has been divided into a three-fold division on the basis of its lithologic character. There it has a thickness of at least nine thousand feet. In King County stratigraphic measurements give a thickness of nearly eight thousand feet of sediments which may also be divided into three divisions. In the western part of King County, south of Seattle, these brackish water sediments become partially marine and yield a distinctly Tejon fauna. South, in Lewis County, distinctly Tejon marine faunas occur interbedded with the brackish water beds.

In southern Lewis County, east of Little Falls, there exist shales and shaly limestones containing a fauna seemingly older than the typical Tejon, but more closely related to it than to the Martinez or Lower Eocene of California. A very large number of the species are new and the fauna may represent a transition from the Martinez to the Tejon—a fauna which as yet is unknown in California. In order to distinguish this from the typical Tejon, the term Cowlitz formation is suggested.

The basaltic lavas and tuffs occurring within the Eocene of western Washington have a thickness ranging from fifteen hundred to two thousand feet. They do not constitute a single flow but rather a series of flows poured out on the sea floor at intervals during the deposition of the sediments. They vary in thickness from point to point. Much of this material is tuffaceous and agglomeratic and for the most part has been forced up from below through numerous fissures and small vents rather than through large central volcanic cones.

During the Tejon, volcanic activity prevailed over all of western Washington with the exception of the central and northwestern portion of the Olympic Peninsula. The same may be said concerning the Coast Ranges of northwestern Oregon. With one or two local exceptions, no volcanic materials are found associated with any of the Oligocene or Miocene strata in western Washington. In the Cascades and eastern Washington they constitute the larger part of the later Tertiary.

COWLITZ FORMATION.

The Cowlitz formation contains the following fauna:

PELECYPODA.

Barbatia morsei Gabb
Cardium breweri Gabb
Cardium cooperi Gabb
Corbula sp.
Crassatella washingtoniana n. sp.
Crassatella cowlitzensis n. sp.
Meretrix olequahensis n. sp.
Ostrea fettkei n. sp.
Pecten cowlitzensis n. sp.
Plauconomia inornata Gabb
Venericardia alticosta Gabb
Venericardia planicosta Lamarck

GASTEROPODA.

Ancillaria bretzii n. sp.
Cassidaria washingtoniana n. sp.
Conus cowlitzensis n. sp.
Cylichna costata Gabb
Fusus lewisensis n. sp.
Fusus dickersoni n. sp.
Fusus washingtoniana n. sp.
Galerus excentricus Gabb
Hemifusus sopenahensis n. sp.
Hemifusus cowlitzensis n. sp.
Hemifusus lewisensis n. sp.
Hemifusus tejonensis n. sp.
Hemifusus washingtoniana n. sp.
Fasciolaria washingtoniana n. sp.
Lunatia lewisii Gould
Murex sopenahensis n. sp.
Murex cowlitzensis n. sp.
Mitra washingtoniana n. sp.
Morio tuberculatus Gabb. var. trituberculatus n. var.
Nassa eocenica n. sp.
Nassa packardi n. sp.
Naticinia obliqua Gabb.
Ranella washingtoniana n. sp.
Ranella cowlitzensis n. sp.
Ramilla canalifera Gabb var. elongata n. var.
Strcula cowlitzensis n. sp.
Tritonium sopenahensis n. sp.
Turritella uvasana Conrad.

BRACHYOPODA.

Rhynconella washingtoniana n. sp.

SHARK'S TEETH.

There is a total of forty-five species occurring in this formation. Out of the total fauna thirty are new species. The base of this formation is unknown. Its known thickness is at least five hundred feet. Future studies may show this to be really a part of the Tejon formation.

TEJON FORMATION.

The Tejon formation contains the following fauna:

PELECYPODA.

Barbatia morsei Gabb.
Cardium breweri Gabb.
Cardium olequahensis n. sp.
Ostrea idriaensis Gabb.
Ostrea olequahensis n. sp.
Pecten peckhami Gabb.

Crassatellites grandis Gabb.
Corbicula cowlitzensis n. sp.
Corbicula eufaulaensis n. sp.
Leda gabbi Conrad.
Meretrix landesi n. sp.
Meretrix horni Gabb.
Meretrix ovalis Gabb.
Meretrix uvasana Conrad.
Modiola ornata Gabb.
Nerverita subglobosa Gabb.
Planconomia inornata Gabb.
Pectunculus eocenica n. sp.
Pectunculus eocenica n. sp. var. landesi n. var.
Pectunculus tejonensis n. sp.
Pectunculus sagittata Gabb.
Solen parallelus Gabb.
Tapes washingtoniana n. sp.
Tellina horni Gabb.
Venericardia planicosta Lamarck.

GASTEROPODA.

Amauropsis alveata Conrad.
Brachysphingus clarkii n. sp.
Cylichna costata Gabb.
Ficus mammilatus Gabb.
Fusus remondi Gabb.
Fusus sp.
Potamides lewisensis n. sp.
Potamides fettkei n. sp.
Potamides carbonicola Cooper.
Turritella uvasana Conrad.

SCAPHAPODA.

Dentalium cooperi Gabb.

This fauna is characteristic wherever the marine Upper Eocene is found. It is typically Tejon and it seems best to retain that formational name within this state. The strata involved in the Puget formation are the brackish water equivalents of the marine Tejon. The Tejon is widely distributed and composes practically all of the Eocene outcrops in western Washington. Indirect evidence suggests its correlation with the Roslyn formation of eastern Washington. The data bearing upon this subject will be presented in a future paper.

OLIGOCENE.

GENERAL STATEMENT.

In southern Thurston County strata occur containing a fauna having a very close relationship to the Tejon below. No distinct unconformity can be recognized. So far as observed the strata are entirely of marine origin. The known area is so small that it has not been represented upon the accompanying map. The best exposures outcrop on Lincoln Creek near the boundary line between Lewis and Thurston counties. The total thickness is less than one thousand feet. Upwards it grades into the Porter shales which are correlated with the lower portion of the Blakeley formation in the type section in Kitsap County. Many of the species occurring at Lincoln

Creek are identical with those at Porter, but the fauna as a whole contains a larger percentage of distinctly Tejon species. These strata may be designated as the Lincoln formation. So far as the writer has been able to ascertain they are marine deposits which as yet have not been definitely recognized at any other locality on the coast. They seem to correspond to the time interval represented by unconformities elsewhere. Lithologically they are largely composed of shales or sandy shales with a very little sandstone and no volcanic material. Volcanic activity in western Washington seems to have entirely ceased at the close of the Eocene.

In the type section of the Blakeley formation at Restoration Point, there is a series of shales and sandy shales which are non-fossiliferous and lie below the fossiliferous beds at Port Blakeley and which seem to rest upon an old basaltic mass of probable Eocene age which may possibly correspond to the fossiliferous beds in the Lincoln formation. These outcrop on the south side of Sinclair Inlet opposite Seattle. In the thick series of sediments exposed in the Cape Flattery section there are about 5,000 feet of non-fossiliferous shales and sandy shales. These underlie the thick massive conglomerates forming the backbone of the Cape and are above the old Mesozoic metamorphic mass which constitutes Portage Head. These beds also may represent those at Lincoln Creek but at present there is no definite evidence to make such a correlation.

The following list of species constitutes the fauna characteristic of the Lincoln formation:

PELECYPODA.

Anomia cf subcostata Conrad.
Leda gabbi Conrad.
Marcia oregonensis Conrad.
Meretrix uvasana Conrad.
Pecten porterensis n. sp.
Solen conradi Dall.
Solen parallelus Gabb.

GASTEROPODA.

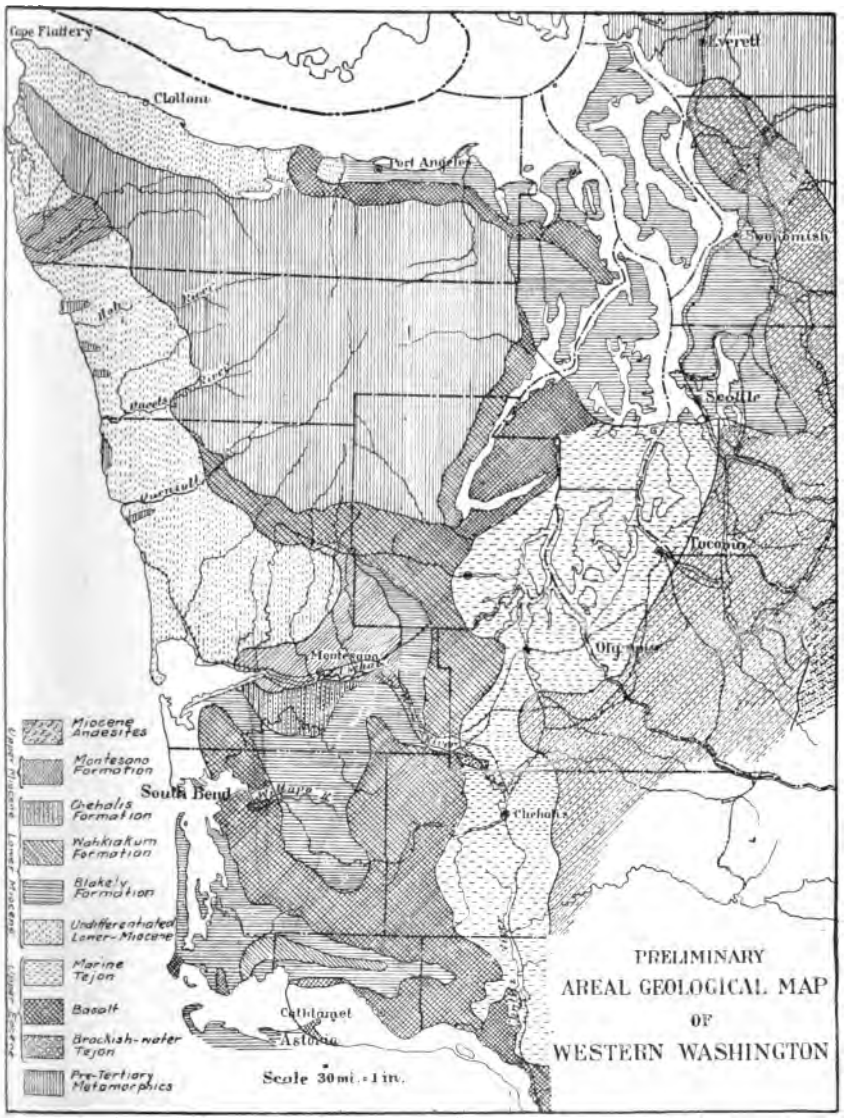
Pleurotoma fresnoensis Arnold.
Pleurotoma lincolnensis n. sp.

CEPHALOPODA.

Aturia angustata Conrad.

BRACHIOPODA.

Terebratula oakvillensis n. sp.


Cape Flattery
Clallam
Port Angeles
Everett
Seattle
Tacoma
Olympia
Montesano
South Bend
Chehalis
Cathlamet
Astoria
Miocene Andesites
Montesano Formation
Chehalis Formation
Wahkiakum Formation
Blakely Formation
Undifferentiated Lower Miocene
Marine Tejon
Basalt
Brackish-water Tejon
Pre-Tertiary Metamorphics
Scale 30 mi. = 1 in.
PRELIMINARY
AREAL GEOLOGICAL MAP
OF
WESTERN WASHINGTON

POST EOCENE.

GENERAL STATEMENT.

The Miocene is distinctly separated into an upper and lower division by a well marked unconformity. The lower division is widely distributed, is marine, and can be subdivided into three formations on a stratigraphic, lithologic, and fauna basis. It has a maximum thickness of twenty thousand feet. The Upper Miocene is restricted to two small areas, has a thickness of five thousand feet and a large and distinctive fauna somewhat similar to the San Pablo of California.

The Lower Miocene deposits are by far the best developed and constitute a large part of the areal geology from the Columbia River northward to the southern foothills of the Olympic Mountains and extend also as a narrow belt around the central core of those mountains. Where not covered over with glacial drift they outcrop in the Puget Sound Basin and in the lower foothills of the Cascades. The Lower Miocene may be divided into three divisions which may be termed the Blakeley, Wahkiakum and Chehalis formations. Those deposits in the Upper Miocene may be designated as the Montesano formation.

No Pliocene deposits are known.

LOWER MIOCENE.

BLAKELEY FORMATION.

The type section of this formation occurs at Restoration Point, Kitsap County, opposite Seattle, and consists of about eight thousand feet of shales and alternating beds of shales and sandstones overlaid with nearly one thousand feet of conglomerates which are non-fossiliferous. The Blakeley beds are exposed in part at Alki Point, Georgetown, the Newcastle Hills, Cathcart, the Quimper Peninsula, in Chehalis County, and at various points along the Strait of Juan de Fuca. At all of these localities the rocks contain a similar fauna. In this report the Cape Flattery section is regarded as Lower Miocene but has not been differentiated into three divisions; nevertheless a large part of it corresponds to the Blakeley beds at Restora-

tion Point. These strata have been considered Oligocene, or at least in part Oligocene, but with the data now at hand the writer feels warranted in placing them in the Lower Miocene. When a definite understanding has been arrived at as to what is to constitute the Oligocene it may be possible to assign them permanently to that period. The following fauna is characteristic of the Blakeley formation:

PELECYPODA.

Cardium cooperi Gabb var. lorenzianum Arnold.
Cardium vaqueroensis Arnold.
Chione cathcartensis n. sp.
Crenella porterensis n. sp.
Macoma calcarea Gmelin.
Macoma moliana Dall.
Marcia oregonensis Conrad.
Modiolus inflatus Dall.
Modiolus directus Dall.
Mytillus stillaguamishensis n. sp.
Mytillus sammamishensis n. sp.
Mytillus snohomishensis n. sp.
Macoma snohomishensis n. sp.
Malitia chehalisensis Arnold.
Nucula dalli.
Nucula gettysburgensis Reagan.
Ostrea veatchii Gabb.
Pecten peckhami Gabb.
Pecten fucanus Dall.
Pecten propatulus Conrad.
Pecten coosensis Shumard.
Phacoides acutilineatus Conrad.
Solemya ventricosta Conrad.
Tellina oregonensis Conrad.
Tellina conjesta Conrad.
Teredo sp.
Thracia trapezoidea Conrad.
Thyasira bisecta Conrad.
Yoldia submontereyensis Arnold.
Yoldia sammamishensis n. sp.

SCAPHAPODA.

Dentalium conradi Dall.

GASTEROPODA.

Ampulina oregonensis Dall.
Astraea sp.
Chlorostoma arnoldi n. sp.
Caliostoma delazinensis n. sp.
Chrysodomus rectrorostris Carpenter.
Chrysodomus clallamensis n. sp.
Drillia chehalisensis n. sp.
Epitonium condoni Dall.
Epitonium oregonensis Dall.
Epitonium rugiferum Dall.
Epitonium petrosum.
Eudolium petrosum Conrad.
Fusinus coosensis Dall.
Fusus stanfordensis.
Mioplejona indurata Conrad.
Pleurotoma fresnoensis Arnold.
Pleurotoma washingtoniana n. sp.
Scaphander oregonensis Dall.
Turritella blakeleyensis n. sp.
Turritella porterensis n. sp.
Turricula washingtoniana Dall.

CEPHALOPODA.

Aturia angustata Conrad.

ECHINODERMATA.

Cidaroid spines.

CRUSTACEA.

Crabs (very abundant).

WORM BORINGS.

PLANT REMAINS.

WAHKIAKUM FORMATION.

Certain strata occurring on the north side of the Columbia River in Wahkiakum County near the head of the Alockaman River have a fauna quite different from that characteristic of the Blakeley formation. These strata consist of approximately four thousand feet of sandstones, shales and grits, with sandstones predominating. They rest unconformably upon a series of shales whose faunal position cannot be definitely ascertained, although it seems to correspond to the Blakeley and the Astoria in Oregon. It is largely covered with Pleistocene sands and gravels. These beds seem to be most closely related to the lower Monterey of California. The following species have been found in this formation.

PELECYPODA.

Arca montereyana.
Chione securis Shumard.
Diplodonta paralis Conrad.
Leda acuta Conrad.
Mactra coalingensis Arnold.
Marcia oregonensis Conrad.
Macrocallista vespertina Conrad.
Nucula gettysburgensis Reagan.
Nucula conradi Meek.
Nucula dalli.
Pecten propatulus Conrad.
Pecten alockamanensis n. sp.
Phacoides acutilineatus Conrad.
Solen conradi Dall.
Spisula albaria Conrad.
Tellina albaria Conrad.
Thracia trapezoidea Conrad
Yoldia strigata Dall.

SCAPHAPODA.

Dentalium conradi Dall.

GASTEROPODA.

Calyptraea filosa Gabb.
Fusus stanfordensis.
Fusinus coosensis Dall.
Cuma biplicata Gabb var. quadranodosum n. var.
Crepidula princeps Conrad.
Strepsidura oregonensis Dall.

CEPHALOPODA.

Aturia angustata Conrad.

CHEHALIS FORMATION.

Certain strata possessing a fairly constant lithologic character and a fairly distinct fauna occur in the hills south of the

Chehalis River in Chehalis County. These are designated as the Chehalis formation. They are prevailingly sandy shales and shaley sandstones, the former predominating. They have a characteristic gray to browinsh gray color and a maximum thickness of about seven thousand feet. They rest unconformably upon the Blakeley formation as well as beneath the Upper Miocene sandstones although in one locality the upper portion of the formation may be transitional into the Upper Miocene. If so this portion represents sediments deposited during the time interval between the Lower and Upper Miocene. A part of the fauna ranges down into the Blakeley and a part up into the Upper Miocene, yet there are many species which are distinctive of these strata only. It is quite possible that these beds may be the equivalent of the upper Monterey of California. The following fauna occurs in this formation:

PELECYPODA.

Leda chehalisensis n. sp.
Macoma wynootcheensis n. sp.
Macoma calcarea Gmelin.
Mytilus inflatus.
Nucula dalli Arnold.
Nassa andersoni n. sp.
Pecten coosensis Shumard.
Phacoides acutilineatus Conrad.
Phacoides annulatus.
Solemya ventricosta Conrad.
Spisula albaria Conrad.
Thracia trapezoidea Conrad.
Thyasira bisecta Conrad.
Venericardia chehalisensis n. sp.

GASTEROPODA.

Argobuccinium cammani Dall.
Argobuccinium coosensis Dall.
Chrysodomus clallamensis n. sp.
Cryptomya oregonensis Dall.
Ficus clallamensis n. sp.
Ficus n. sp.
Liomesus sulcatus Dall.
Natica oregonensis Conrad.
Polynices lewisi Gould.
Turris wynootchensis n. sp.
Turris cammani Dall.
Turris coosensis Dall.

CEPHALOPODA.

Aturia angustata Conrad.

SCAPHAPODA.

Dentalium conradi Dall.

PLANT REMAINS.

UPPER MIOCENE.

MONTESANO FORMATION.

Strata of Upper Miocene age outcrop in Chehalis County, north of the Chehalis River, in the vicinity of Montesano. They

consist largely of massive coarse-grained sandstones of a light brown color containing many intercalated lenses of conglomerate and grit. Shales, while subordinate in the lower portion of the formation, are common in the upper. These beds may be designated as the Montesano formation. They possess a maximum thickness of approximately five thousand feet and contain a fairly large fauna which is quite distinct from that in the Lower Miocene. This fauna appears in abundance in the basal conglomerates and is quite persistent throughout the sandstone phase. A very rich fossil locality occurs on Sylvia Creek in conglomerate about six miles north of the town of Montesano in Chehalis County.

The outcrops of this formation occupy an area of about 1,000 square miles in Chehalis County. Farther north on the western side of the Olympic Mountains, in the basin of the Soleduck and Bogachiel rivers, fossiliferous sandstones and shales occur whose fauna is closely related to that of the sandstone portion of the Montesano formation in Chehalis County. It has an estimated thickness of about 500 feet and has been referred to by Reagan* in his report. No deposits of Montesano age are known from the vicinity of the Strait of Juan de Fuca, the Puget Sound Basin, or the eastern and southern portions of southwestern Washington. Apparently these portions of the state were land areas during all of the Upper Miocene as well as Pliocene.

This formation is closely related to the Empire of Coos Bay, Oregon, and to the San Pablo of California. It possesses a characteristic fauna of 61 specimens which are listed below:

PELECYPODA.

Arca trilineata Conrad.
Arca sp.
Cardium corbis Martyn.
Cardium coosensis Dall.
Cardium meekianum Gabb.
Chione securis Shumard.
Chione bisculpta Dall.
Chione temblorensis Anderson.
Nucula conradi Meek.
Panopaea generosa Gould.
Pseudocardium gabbi Remond var. robustum n. var.
Pseudocardium gabbi Remond var. undiliferum n. var.
Pseudocardium gabbi Remond var. elongatus n. var.

*Kansas Academy of Science.

Chione chehalisensis n. sp.
Chione montesanoensis n. sp.
Diplodonta paralis Conrad.
Glycimeris gabbi Dall.
Macoma secta Conrad.
Macoma nasuta Conrad.
Macoma montesanoensis n. sp.
Mactra coalingensis Arnold.
Modiolus piercei.
Mytilus condoni Dall.
Pseudocardium landesi n. sp.
Solen conradi Dall.
Spisula albaria Conrad.
Spisula catiliformis.
Semele montesanoensis n. sp.
Semele sylviaensis n. sp.
Tellina kincaidi n. sp.
Tellina merriami n. sp.
Tellina albaria Conrad.
Tapes staleyi Gabb.

GASTEROPODA.

Bathytoma gabbiana Dall.
Buccinium bogachieli Reagan.
Calyptraea filosa Gabb.
Chrysodomus imperallis Dall.
Chrysodomus bairdi Dall.
Chrysodomus giganticus Reagan.
Columbella ganspata Gould.
Crepidula princeps Conrad.
Cryptomya washingtoniana n. sp.
Eulima smithi Reagan.
Eulima washingtoniana n. sp.
Fusinus montesanoensis n. sp.
Gyrineum sylviaensis n. sp.
Gyrineum mediocre var. corbiculatum Dall.
Natica clausa Broderip and Sowerby
Natica oregonensis Conrad.
Neptunea maxfieldi Reagan.
Olivella pedroana Conrad.
Phalium aequisulcatum Dall.
Polynices lewisi Gould.
Ranella marshalli Reagan.
Sinum scopulosum Conrad.
Thais etchegoinensis Arnold

SCAPHAPODA.

Dentalium conradi Dall.

ECHINODERMATA.

Scutella gabbi Remond.

SHARK'S TEETH.

PLANT REMAINS.

GEOLOGIC HISTORY.

Concerning the geological conditions in western Washington during the Palaeozoic, very little data is at hand. Exposures in the western Cascades suggest that the region at least during the Carboniferous was an open sea with islands or the mainland not far away. Lavas and tuffs seem to have been poured out over the sea floor where they now occur interbedded with sediments. Similar conditions seem to have prevailed during the Triassic and Jurassic. Deep sea marine deposits laid down during these two periods occur in the Olympic Mountains, in the San Juan Islands, in Vancouver Island and in the Cascade

Mountains. There is a strong suggestion that they were a part of the same seas which are known to have existed in Idaho and northern Nevada.*

In Washington at or near the close of the Jurassic there was a series of crustal movements accompanied by intrusions of basic and acidic plutonic magmas. The larger part of Washington seems to have been uplifted above sea level and the older sedimentary formations metamorphosed. Evidence obtained indicates that the upward movement of the earth's crust was differential, resulting in the development of an elevated mountain mass trending in a general northwest direction and occupying the present position of the Okanogan Highlands, the northern Cascades and Vancouver Island. The San Juan Islands and the Olympic Mountains are included in this. A similar uplift at the same time occurred in southern Oregon and northern California.

The area involved between this mountain mass in northern Washington and the Klamath Mountains in southern Oregon, appears for the most part to have been above sea level during the Cretaceous. No Cretaceous deposits of any kind are known to occur within this area, although it is possible there may have been a marine connection with eastern Oregon, somewhere to the north or south of the present site of the Columbia River.

In southern Oregon arms of the sea are known to have extended southward into the Klamath Mountains. On the north side of Vancouver Island and the San Juan Islands, non-metamorphosed marine Cretaceous deposits do occur. They are restricted, however, to the Chico formation or Upper Cretaceous. In the Klamath region all three divisions of the Cretaceous are present.

Crustal movements initiated at or near the close of the Jurassic, and continuing in a milder form during the Cretaceous, are assumed to have developed a structural basin which has served for the accumulation of marine, brackish and fresh water sediments together with lavas and tuffs during the whole of the Tertiary era. The Tertiary history of this area is a

*22nd Ann. Rep't U. S. G. S., pt. 2, p. 580, 1901.

distinct unit in itself and may be referred to as the Pacific Northwest Tertiary Province.

In western Washington the Eocene seems to have been ushered in by a gradual and differential submergence of the land area allowing the marine seas to transgress eastward. Embayments developed and extended eastward to the present position of the western slope of the Cascades. The southern portion of this range of mountains apparently did not exist as such during the Eocene and Miocene but seems to have been occupied by a series of fresh water lakes which at times may have been connected with the brackish water estuaries farther to the west.

The geographical position of the land and water areas was continually shifting during the Eocene. This was caused partly by a continual differential elevation and depression of the entire area involved in this province and partly by the silting up of the basins of deposition. Evidences from fauna and flora point to tropical conditions during the Eocene. At intervals arms of the sea appear to have been cut off and to have become brackish, and certain of its marine fauna developed into brackish water types.

The Eocene as a whole may be characterized by a continual shifting of shore lines. The present line of the Northern Pacific railroad between Seattle and Portland may be taken roughly as the eastern limit of the marine shore line although at times marine embayments seem to have extended further east. At times the shore line was farther west.

The later portion of the Eocene was also characterized by the extrusion of basaltic lavas and tuffs which came up through numerous fissures. These deposits of igneous material often accumulated on the sea floor and were covered by marine sediments and then again by further outpourings of basaltic materials. This seems to have been repeated many times until it absolutely ceased at the close of the Eocene. Volcanic activity did not occur during the Miocene or Pliocene west of the present foothills of the Cascade mountains.

In Washington the time interval immediately following Eo-

cene sedimentation and vulcanism is characterized by evolution of the marine faunas. This change consisted in the development of species adapted to the environment of a colder climate than that of the Eocene. This time interval is designated as the Oligocene.

No sharp break separates the Miocene from the Oligocene. The conditions existing during the early portion of the Miocene were somewhat similar to those of the Eocene. Oscillations of the sea floor were more or less continuous and the marine fauna has a much closer relationship to that of the present day. No brackish water beds are known to have existed nor have any evidences of volcanic activity been observed. About the middle of the Miocene there appears to have been an extensive elevation of the sea floor so as to have elevted above sea level almost the entire area of this northwestern Tertiary province. During the upper Miocene, local depressions or embayments were developed in which accumulated the sandstones and shales of the Montesano formation. These are typically developed on the north side of the Chehalis Valley and in the valleys of the Soleduck and Bogachiel rivers in the Olympic Peninsula.

Nearly all of southwestern Washington, the Puget Sound Basin, and the Strait of Juan de Fuca seem to have been land areas during the upper Miocene.

In western Washington no marine deposits of Pliocene age are known. The region appears to have been undergoing erosion. Near the close of the Pliocene, or perhaps during early Pleistocene a series of crustal movements culminated in the uplift of the Cascade mountains of Oregon and Washington into approximately their present position. Within Washington the Cascades are considered to have been a comparatively level plain. Ample evidence is at hand to suggest that this plane was elevated as a differentially warped dome. Its structure consists of a number of folds whose axes have a general northwest to southeast direction. Within the Puget Sound Basin the Tertiary formations seem to have been also involved in a series of closely folded anticlines and synclines, much faulting accom-

panying these movements. In southwestern Washington the structure resulting from these movements has produced two extensive pitching geosynclines. All the Tertiary formations in southwestern Washington, extending from the Columbia River northward to the foothills of the Olympic Mountains are involved in these two geosynclines. The larger of these occupies most of the drainage basin of the Chehalis River and a portion of the Willapa. The other lies largely within the drainage basin of Columbia River and Willapa Bay. The southern limb of this one diagonally crosses the Columbia from Wahkiakum County to Astoria, Oregon. The sandstones and shales at the town of Astoria, including the underlying basalt at Tongue Point, represent a part of the Eocene and Miocene series involved in the south limb of this structural geosyncline. The elevated anticlinal ridge which separates the two geosynclines forms the drainage divide between the Columbia on the south and the Willapa and Chehalis valleys on the north. It is composed almost entirely of Eocene basaltic lavas and appears originally to have been covered over by Miocene sediments which are found to the north and south in the synclinal folds. These strata seem to have been stripped off by erosion.

Extending northward along the Pacific coast of the Olympic Peninsula there are numerous exposures of Miocene sediments which have also been involved in a series of northwesterly pitching synclines. These are separated by broad outcrops of the older formations. Many extensive faults have accompanied this folding.

In the Strait of Juan de Fuca the Miocene formations have been folded into a series of northwesterly pitching synclines. These extend diagonally across the Strait and are represented on the south side of Vancouver Island by a very narrow fringe resting upon the upturned edges of the older metamorphics. This fringe is more or less continuous from Port San Juan to Sooke Bay.*

A further uplift of the Olympic Mountains seems to have

*Unpublished data obtained by writer.

occurred at this time and extensive erosion, aided by a structural depression, partially developed the channels of Puget Sound and the Strait of Juan de Fuca.

The character of the faunas and floras during the progression of the Tertiary period indicate the gradual approach of a colder climate. During the Pleistocene, conditions allowed the accumulation of extensive ice fields in the higher portions of the Cascade Mountains. These gradually increased in volume and traveled down the various river valleys until they coalesced along the eastern margins of the Puget Sound Basin, forming a great piedmont glacier. Similar conditions occurred along the Pacific coast of British Columbia. These vast ice streams traveled southward until they joined with those in the Puget Sound Basin forming one great ice field extending from the Cascades on the east up into the valleys of the Olympic Mountains on the west. One arm of this ice field seems to have turned westward, passed around the northern side of the Olympic Mountains and extended out to sea through the Strait of Juan de Fuca. The southern margin of this arm may be found on the western side of the Olympics a short distance below Ozette Lake. The southern limits of the Puget Sound ice field seem to have extended below Olympia.

Two advances of the ice have been recorded with one interglacial period. Since the final retreat of the glaciers an uplift, ranging from ten to forty feet has occurred. Evidence of this may be seen in raised beaches.

DESCRIPTION OF SPECIES.

UPPER EOCENE SPECIES.

PELECYPODA.

GENUS PECTUNCULUS LAMARCK.

PECTUNCULUS EOCENICA n. sp.

Plate V, Figures 52, 53.

Description.—Shell sub-circular, thin, equivalve, and nearly equilateral; base regularly convex; sides sloping down directly from the beak, the anterior side much more steeply rounded than the posterior, the latter being regularly convex; junction of posterior end and base very slightly truncated. Surface marked by forty broad nearly flat-topped radiating ribs with very narrow interspaces, between which are raised threads; four or five very prominent lines of interrupted growth are present with fainter intervening concentric lines. Hinge robust with radiating teeth; palial line very distinct, inner margin coarsely crenulated.

Dimensions.—Altitude 23 mm.; longitude 25 mm.; thickness 7 mm.

Occurrence.—Very common at Loc. No. 227. (University of Washington Palaeontological Collection).

Horizon.—Tejon formation, Upper Eocene.

PECTUNCULUS EOCENICA n. sp. VAR. LANDESI n. var.

Plate V, Figure 54.

Description.—Shell sub-oval, thin, equivalve, inequilateral; base regularly rounded; posterior margin sloping down sharply to the posterior end; anterior margin sloping at an angle of 25 degrees for a short distance, then broadly rounded toward the anterior end; beaks small and moderately incurved. Surface marked by thirty radiating ribs, broad and flat-topped with narrow interspaces. Interior margin coarsely crenulated; hinge robust with radial teeth. A large number of specimens of this variety have been collected and each is characterized by the steeply sloping truncated posterior margin.

Dimensions.—Altitude 29 mm.; longitude 27 mm.; thickness 7.5 mm.

Occurrence.—Common at Loc. No. 227 (University of Washington Palaeontological Collection).

Horizon.—Tejon formation, Upper Eocene.

PECTUNCULUS TEJONENSIS n. sp.

Plate XV, Figure 134.

Description.—Shell moderately large, thick, elongated, equivalve and nearly equilateral; posterior and anterior margins very slightly convex, sloping steeply and nearly equally from the beak where they meet at a sharp angle; below they gradually grade into the base which is broadly and regularly rounded (posterior margin slightly more convex than anterior); beaks fairly prominent and incurved; a very slight depression on the posterior side of the umbones. Surface sculptured by numerous well-developed lines of growth and about thirty fairly distinct radiating ribs which are broad and flat with very narrow intermediate grooves.

Dimensions.—Altitude 33 mm.; longitude 29 mm.; thickness 11 mm.

Occurrence.—Abundant at Loc. No. 227. (University of Washington Palaeontological Collection).

Horizon.—Tejon formation, Upper Eocene.

GENUS OSTREA LINNAEUS.

OSTREA OLEQUAHENSIS n. sp.

Description.—Shell medium sized, slightly inequilateral, wide, thick, slightly curved; lower valve very convex and nearly smooth except for irregular wavy lines of growth; a faint radial sculpture is present in some specimens. Central portion of valve most convex with marked slope; posterior margin sloping at a steep angle and broadly rounded; anterior margin gradually and nearly straight to the anterior end which is acutely rounded; base broadly rounded; upper valve about one-half as convex as lower.

Dimensions—Altitude 55 mm.; longitude 48 mm.; thickness of lower valve 24 mm.

Occurrence.—Common at Loc. No. 2 (University of Washington Palaeontological Collection). On Olequah Creek, one mile above junction of Olequah and Stillwater creeks, back of the Cantwell place in Sec. 29, T. 11 N., R. 2 W.

Horizon.—Tejon formation, Upper Eocene.

OSTREA FETTKEI n. sp.

Plate IV, Figures 37, 39.

Description.—Shell small, thin, somewhat curved, right valve nearly flat, left valve convex; hinge deflected to the left and median groove very well marked; internal margins in both old and young forms are pitted; shell inequivalve and slightly inequilateral; left valve ornamented by a marked median ridge extending from beak to basal margin; anterior to this ridge are two radiating ribs becoming obsolete toward the beaks; posterior surface with six radiating ribs extending to the beak; these are crossed by a large number of concentric ribs and lines of growth.

Dimensions.—Left valve, altitude 27 mm.; longitude 17 mm.; thickness 7 mm.

Occurrence.—Common at Loc. No. 1 (University of Washington Palaeontological Collection). One-half mile east of Sopenah (Little Falls) in the bank of the Cowlitz River, Lewis County, Sec. 27, T. 11 N., R. 2 W.

Horizon.—Cowlitz formation, Upper Eocene.

GENUS PECTEN MULLER.

PECTEN COWLITZENSIS n. sp.

Plate V, Figure 46.

Description.—Shell small, somewhat higher than long, thin, nearly equivalve, equilateral, and with very slightly serrate margins; anterior and posterior margins slightly concave, sloping equally and steeply from the beak and merging into the regularly rounded base; angle at which margins intersect at beak is

80°; surface ornamented by forty-four equally spaced broadly rounded radiating ribs, separated from each other by narrower flat-bottomed to slightly concave interspaces; hinge line nearly two-thirds the length of the shell; ears unequal; surface sculptured by numerous fine concentric lines of growth.

Dimensions.—Altitude 17 mm.; longitude 14.5 mm.; thickness 2.5 mm.

Occurrence.—At Loc. No. 1 (University of Washington Palaeontological Collection). One and one-half miles east of Sopenah (Little Falls) in the bluffs of the Cowlitz River, Lewis County, Sec. 27, T. 11 N., R. 2 W.

Horizon.—Cowlitz formation, Upper Eocene.

GENUS CRASSATELLITES KRUGER.

CRASSATELLITES COWLITZENSIS n. sp.

Plate IV, Figure 40.

Description.—Shell small, comparatively thin, sub-triangular to sub-quadrate; beak situated about one-third the length of the shell from the anterior end; anterior margin slopes down steeply at first and then at an angle of 30° to the anterior end, which is sharply arcuate; base broadly rounded, with pronounced upward slope at the anterior end; posterior margin nearly straight and sloping down to the posterior end where it is abruptly truncated; an angular ridge extends from beak to posterior end and is situated a little in front of the posterior margin. Surface sculptured by numerous well developed concentric lines of growth. Lunule long, narrow, and not very deeply impressed; escutcheon absent; hinge plate not very heavy; muscular scars well developed as well as palial line.

Dimensions.—Altitude 20 mm.; longitude 26 mm.; thickness 5 mm.

Occurrence.—At Loc. No. 1 (University of Washington Palaeontological Collection). One and one-half miles east of Sopenah (Little Falls) in bank of Cowlitz River, Lewis County, Sec. 27, T. 11 N., R. 2 W.

Horizon.—Cowlitz formation, Upper Eocene.

CRASSATELLITES WASHINGTONIANA n. sp.

Plate IV, Figure 42, and Plate V, Figure 51.

Description.—Shell of moderate size, elongate, sub-trigonal, thick, equivalve, and very inequilateral; beaks about one-fourth of the length of the shell from the anterior end; incurved and pointing slightly forwards; anterior margin straight and sloping downwards steeply at an angle of 60°. It is then broadly rounded and merges into the base; posterior margin very slightly convex and sloping downwards at an angle of 25°; posterior end broadly truncated; base broadly rounded; a fairly distinct ridge passes downwards on the surface from beak to posterior end and is situated a little in front of the posterior margin; lunule cordate, fairly large, distinct and deeply impressed. Surface sculptured by a well defined series of concentric ribs and lines of growth. Palial line distinct and some distance from margin of shell; muscle scars strong and nearly equally developed; hinge plate heavy and teeth typically developed.

Dimensions.—Altitude 26 mm.; longitude 34 mm.; thickness 10 mm.

Occurrence.—At Loc. No. 1 (University of Washington Palaeontological Collection). One and one-half miles east of Sopenah (Little Falls) in banks of Cowlitz River, Lewis County, Sec. 27, T. 11 N., R. 2 W.

Horizon.—Cowlitz formation, Upper Eocene.

GENUS CORBICULA MEGERLE.

CORBICULA EUFAULAENSIS n. sp.

Plate XIV, Figure 119, and Plate XV, Figure 131.

Description.—Shell sub-circular, about one-fifth longer than high and very thick; beaks very prominent and situated nearly central, sometimes anterior to the center; valves very convex; anterior and posterior margins sloping at nearly the same angle, the former very slightly concave and the latter very slightly convex; both ends acutely but evenly rounded. Surface sculp-

tured by prominent concentric lines of growth. Hinge plate and teeth well developed.

Dimensions.—Altitude 32 mm.; longitude 38 mm.; thickness 12.5 mm.

Notes.—Beds over five feet in thickness, composed exclusively of the remains of this genus. These beds represent a brackish water phase of the Tejon formation and are overlaid and underlaid by marine beds. This intercalation of marine and brackish water strata is repeated several times in Cowlitz and Lewis counties.

Occurrence.—Very common at Loc. No. 8 (University of Washington Palaeontological Collection) on Coal Creek, one mile north of Inmann-Polson store, Cowlitz County, Sec. 35, T. 9 N., R. 3 W.

Horizon.—Brackish water Tejon, Upper Eocene.

CORBICULA COWLITZENSIS n. sp.

Plate XIV, Figure 117, and Plate XV, Figures 132, 135.

Description.—Shell sub-triangular in outline, nearly one-fourth longer than high, thick; beaks prominent, elevated and situated about two-fifths the length of shell from the anterior end; valves convex; anterior margin slightly concave, short and sloping downwards at an angle of 50°; anterior end broadly rounded; basal margin evenly but very slightly rounded; posterior margin nearly straight, long and sloping downwards at an angle of 30°; posterior end obliquely truncated and narrow. Surface marked by well developed concentric lines of growth. Hinge plate thick, cardinal teeth very large, lateral teeth prominent.

Dimensions.—Altitude 28 mm.; longitude 36 mm.; thickness 10 mm.

Occurrence.—Common at Loc. No. 8 (University of Washington Palaeontological Collection) on Coal Creek one mile north from Inmann-Polson store, Cowlitz County, Sec. 35, T. 9 N., R. 3 W.

Horizon.—Brackish water Tejon, Upper Eocene.

GENUS CARDIUM LINNAEUS.

CARDIUM OLEQUAHENSIS n. sp.

Plate V, Figure 55.

Description.—Shell moderate in size, inequilateral, and about as long as wide; beak central, incurved and inclined considerably forwards; anterior margin slightly concave sloping downwards rather steeply and merging into the base which is regularly rounded; posterior margin convex sloping downward steeply and finally becoming vertical; posterior end slightly truncated. A prominent ridge extends from the beak to the base on the surface of the shell a little in front of the posterior margin. Surface ornamented by forty very slightly rounded radiating ribs which are very prominent on the central portion of the surface but less distinct near the anterior margin; interspaces are flat and about three-fourths the width of the ribs. These are crossed by concentric lines of growth.

Dimensions.—Altitude 20 mm.; longitude 20 mm.; thickness 6.5 mm.

Occurrences.—At Loc. No. 6 (University of Washington Palaeontological Collection). About one mile west of the junction of the Stillwater and Olequah creeks, on the former stream.

Horizon.—Tejon formation, Upper Eocene.

GENUS MERETRIX LAMARCK.

MERETRIX LANDESI n. sp.

Plate IV, Figures 41, 43.

Description.—Shell large, sub-triangular and thick; beak situated slightly anterior to the center, prominent and directed forwards; anterior margin slightly concave and sloping downward at an angle of 45°; anterior end acutely rounded; posterior margin slightly concave and sloping less steeply to the posterior end; base broadly and evenly rounded; surface ornamented by well developed nearly equally spaced concentric lines of growth; no radiating ribs present. Lunule large, cordate, and deeply impressed; escutcheon much larger and also

impressed; hinge plate heavy; lateral teeth well developed; muscular scars large.

Dimensions.—Altitude 53 mm.; longitude 68 mm.; thickness 20 mm.

Occurrence.—At Loc. No. 2 (University of Washington Palaeontological Collection). On Olequah Creek one mile above junction with Stillwater Creek, back of the old Cantwell place.

Horizon.—Tejon formation, Upper Eocene.

MERETRIX OLEQUAHENSIS n. sp.

Plate V, Figures 47, 48, 49, 50.

Description.—Shell thick, robust, somewhat inflated, sub-triangular; beaks nearly central, prominent and strongly incurved; anterior margin sloping downward steeply and nearly straight, then extending outward with a decreasing slope until broadly truncated at the anterior end; base evenly rounded; posterior margin sloping steeply at first then decreasing and merging into the broadly rounded posterior end. Surface sculptured with somewhat prominent concentric ribs. No radiating ribs are present. Surface deeply excavated under the beaks. Inner surface smooth with strong pits and moderately deep palial sinus; lateral teeth well developed.

Dimensions.—Altitude 35 mm.; longitude 38 mm.; thickness 15 mm.

Occurrence.—At Loc. No. 2 (University of Washington Palaeontological Collection).. On Olequah Creek, one mile above junction of Olequah and Stillwater creeks, west of the Cantwell place.

Horizon.—Tejon formation, Upper Eocene.

GENUS TAPES MEGERLE.

TAPES WASHINGTONIANA n. sp.

Description.—Shell of moderate size, thin and inequilateral; beaks about one-third the length of shell from anterior end and directed forwards; anterior margin concave and sloping at an angle of 45° to the anterior end which is very acutely rounded;

base broadly rounded; posterior margin slightly convex and sloping at a very low angle to the posterior end where it is broadly truncated. Surface ornamented by numerous well developed concentric ribs and lines of growth; no radiating ribs present. Lunule large, distinct and somewhat narrow, escutcheon absent.

Dimensions.—Altitude 25 mm.; longitude 32 mm.; thickness 7 mm.

Occurrence.—At Loc. No. 6 (University of Washington Palaeontological Collection). About one mile west of the junction of Stillwater and Olequah creeks, on the former.

Horizon.—Tejon formation, Upper Eocene.

GASTEROPODA.

GENUS POTAMIDES BRONGT.

POTAMIDES FETTKEI n. sp.

Plate II, Figures 23, 24.

Description.—Shell small, elongated, and turreted; whorls nine, very slightly convex and somewhat angulated; suture fairly distinct and linear. Surface ornamented with thirteen revolving ribs, three above and ten below the revolving angle; each rib is set with numerous small beadlike nodes. Between each set of nodose ribs there is a small revolving thread which is smooth. The revolving angle is set with ten large flattened nodes; whorls of spire similarly sculptured. Aperture moderately broad, ovate; inner lip very slightly thickened; outer lip smooth.

Dimensions.—Altitude 19 mm.; diameter 5 mm.; angle of spire 23°.

Occurrence.—Common at Loc. No. 2 (University of Washington Palaeontological Collection). On Olequah Creek one mile above junction with Stillwater Creek, back of Cantwell place, Sec. 29, T. 11 N., R. 2 W.

Horizon.—Tejon formation, Upper Eocene.

POTAMIDES LEWISIANA n. sp.

Plate II, Figures 22, 25.

Description.—Shell small, elongate, turreted; whorls nine to ten, slightly convex and in some specimens faintly angulated. Suture distinct and impressed. Surface sculptured by fourteen distinct revolving ribs each of which is set with small beadlike nodes; no intervening revolving threads present. Longitudinal ribs are sometimes present, sometimes confined to the whorls of the spire only and sometimes confined to the body whorl. The faint angulation which is often present is confined to the surface just below the suture. Aperture narrow and elliptical; inner lip incrusted; outer lip thin.

Dimensions.—Altitude 24 mm.; diameter 7 mm.; angle of spire 20°.

Occurrence.—Common at Loc. No. 2 (University of Washington Palaeontological Collection.) On Olequah Creek one mile above junction with Stillwater Creek, back of Cantwell place, Sec. 29, T. 11 N., R. 2 W.

Horizon.—Tejon formation, Upper Eocene.

GENUS RIMELLA AGASSIZ.

RIMELLA CANALIFERA GABB, var. ELONGATA n. var.

Plate II, Figures 18, 19.

Description.—Shell small, fusiform, elongate; spire very much elevated; whorls ten (a constant character), slightly convex; suture moderately deep. Surface marked by twenty-three narrow knife-like longitudinal ribs. These extend over all the whorls except the last two which form the apex; interspaces twice as broad as the ribs and broadly concave. These ribs extend over the upper two-thirds of the body whorl and over all the whorls of the spire. They are crossed by thirty-three distinct revolving ribs which are very closely spaced on that part of the surface where the longitudinal ribs are present; below that the revolving ribs are twice as far apart. Aperture long and narrow; posterior angle of the mouth is continued in a deep canal (in some specimens fairly broad), slightly curved

along the spire to the apex; anterior canal short; outer lip somewhat thickened; inner lip heavily incrusted by a callous.

Dimensions.—Altitude 19 mm.; diameter 7 mm.; altitude of spire 11 mm.; angle of spire 32°.

Notes.—This variety is characterized by ten instead of six or seven whorls, by its more slender form, and differences in external ornamentation. Specimens are numerous and excellently preserved.

Occurrence.—Common at Loc. No. 1 (University of Washington Palaeontological Collection), one and one-half miles east of Sopenah (Little Falls) in bank of Cowlitz River, Lewis County, Sec. 27, T. 11 N., R. 2 W.

Horizon.—Cowlitz formation, Upper Eocene.

GENUS CASSIDARIA LAMARCK.

CASSIDARIA WASHINGTONIANA n. sp.

Plate III, Figure 28.

Description.—Shell large, thick, angulated, globularly ovate and profusely ornamented; whorls eight, upper three smooth and rounded; body whorl large; spire relatively short. On the spire are two very large revolving ribs or carinae which are set with tubercles or spines. The carinae form an upper and lower angle to the whorl; between these the surface is concave; above the upper angle the surface is flat and forms nearly a right angle with the surface of the central part of the whorl. Surface below the lower angle slightly concave and sloping downwards to the canal; on it are two less prominent revolving ribs carrying spines. Whorls of spire are similarly developed. Surface ornamented by eleven longitudinal ribs beginning at the suture and covering the whorl but less conspicuous on the lower portion of whorl. Surface crossed by nine prominent revolving ribs; the upper two situated on the angle of the whorl forming the carinae. Where these intersect the longitudinal ribs, nodes or spines are developed. Sometimes a third carinae is developed. Between each set of the large revolving ribs is one less prominent rib and on either side of that, two small re-

volving threads. Spire similarly ornamented. Suture distinct and slightly undulating. Inner lip expanded and with heavy callous covering the surface up to the upper angle of the body whorl; outer lip thick and crenulated; posterior sinus distinct but small; aperture broad and oval; canal broken.

Dimensions.—Altitude from broken end of spire 44 mm.; diameter 32 mm.; altitude of spire 13 mm.; angle of spire 98°.

Notes.—These specimens are beautifully preserved and in some cases show the original coloring.

Occurrence.—At Loc. No. 1 (University of Washington Palaeontological Collection) one and one-half miles east of Sopenah (Little Falls) in bank of Cowlitz River, Lewis County, Sec. 27, T. 11 N., R. 2 W.

Horizon.—Cowlitz formation, Upper Eocene.

GENUS MORIO MONTF.

MORIO TUBERCULATUS, GABB, VAR. TRI-TUBERCULATUS n. var.

Plate III, Figure 35.

Description.—This form is undobutedly M. tuberculatus Gabb, as described in Vol. 1, Palaeontology of California, but there are certain variations from his original description which are constant on every specimen collected in Washington. Since the California and Washington localities are so widely separated and the material here so perfectly preserved it seems best to place this form on record as a variety. Gabb states that his figure is partially a restoration based on several fragments especially the aperture. Gabb's description is here quoted:

"Shell short, robust, thin; whorls seven, spire low. Surface marked by two, rarely three, rows of small tubercles; two bounding the widest portion of the volution, with a plane or slightly concave surface between them; the third, which occurs rarely, is placed below the others; besides these, the whole surface is ornamented by fine revolving striae. Aperture broad; outer lip thick, longitudinally striate externally, inner surface crenulate; columellar lip covered by a broad plate, plicate or crenulate anteriorly. Canal strongly recurved. A distinct

varix, nearly as large as the outer lip, occurs on the body whorl, and sometimes there is a smaller one on the penultimate volution. I have not always been able to detect the latter."

In the variety of tri-tuberculatus the whorls always carry three rows of tubercles (never only two). The varix on the body whorl is much smaller; canal much more strongly recurved than shown in Gabb's figure; columellar lip less extensively developed; aperture narrower. These variations are characteristic of all specimens collected.

Dimensions.—Altitude 24 mm.; diameter 17 mm.; altitude of spire 4 mm.; angle of spire 85°.

Occurrence.—At Loc. No. 1 (University of Washington Palaeontological Collection) one and one-half miles east of Sopenah (Little Falls) in bank of Cowlitz River, Lewis County, Sec. 27, T. 11 N., R. 2 W.

Horizon.—Cowlitz formation, Upper Eocene.

GENUS TRITONIUM LINK.

TRITONIUM SOPENAHENSIS n. sp.

Plate I, Figure 6.

Description.—Shell fusiform, small and robust; whorls seven and convex; spire moderately elevated. Surface ornamented by ten very prominent, narrow, rounded longitudinal ribs which extend over the whole surface of the shell except the very lowermost part of the body whorl. These ribs are crossed by twenty-one well defined, sinuous, equally spaced and developed revolving ribs with broad concave interspaces. Suture distinct, impressed and sinuous. Aperture subelliptical, narrow and prolonged as nearly closed canal anteriorly. Canal short and slightly bent backwards; inner lip smooth; outer lip crenulated within; varices few and small.

Dimensions.—Altitude 18 mm.; diameter 8 mm.; altitude of spire 7 mm.; angle of spire 58°.

Occurrence.—At Loc. No. 1 (University of Washington Palaeontological Collection) in banks of Cowlitz River, Lewis County, Sec. 27, T. 11 N., R. 2 W.

Horizon.—Cowlitz formation, Upper Eocene.

GENUS RANELLA LAMARCK.

RANELLA WASHINGTONIANA n. sp.

Plate II, Figure 14.

Description.—Shell medium size and robust; spire moderately high; whorls seven to eight, angulated and convex, last two of apex being smooth and not sculptured; body whorl with pronounced revolving angle about one-fourth the length of the whorl down from the suture; surface between angle and suture nearly straight (occasionally slightly concave); surface below the angle broadly convex. Suture compressed, distinct but somewhat undulating; varices prominent, bladelike and continuous. In addition to the varices the surface is ornamented by nine distinct longitudinal ribs. These are crossed by seventeen prominent revolving lines. The one on the angle and the four immediately below it are set with sharp spine like nodes at the intersection with the longitudinal ribs. Surface above the angle sculptured by a very large number of fine revolving threads but no prominent revolving ribs. Between the more prominent revolving ribs below the angle there are numerous fine revolving threads. Aperture broad, sub-oval, narrowing at the posterior end; inner lip not heavily incrusted; canal short and not strongly recurved; outer lip thickened by the varix.

Dimensions.—Altitude 35 mm.; diameter 23 mm.; altitude of spire 17 mm.; angle of spire 60°.

Occurrence.—Very common at Loc. No. 1 (University of Washington Palaeontological Collection) one and one-half miles east of Sopenah (Little Falls) in bank of Cowlitz River, Lewis County, Sec. 27, T. 11 N., R. 2 W.

Horizon.—Cowlitz formation, Upper Eocene.

RANELLA COWLITZENSIS n. sp.

Plate II, Figure 15, and Plate III, Figures 26, 27.

Description.—Shell small and robust; spire high; whorls six, convex and without any angle. Suture distinct and impressed. Varices very large and extending over all of the whorls. Surface sculptured by eight unequally developed longitudinal ribs

extending over the entire surface of the whorls. These are crossed on the body whorl by nine equally developed and equally spaced revolving ribs. Where these intersect the longitudinal ribs, low rounded nodes are developed, which are most conspicuous on the central part of the whorl. Between each of the revolving ribs there are four or five fine revolving threads. Aperture small, elliptical, equally acuminate above and below, anterior end forming a nearly closed canal which is short and strongly curved backwards. Inner lip very heavily incrusted; outer lip thick and crenulated.

Description.—Shell small, fusiform; spire moderately high; spire 12 mm.; angle of spire 40°.

Notes.—Specimens of this species are exceedingly well preserved.

Occurrence.—Very common at Loc. No. 1 (University of Washington Palaeontological Collection) one and one-half miles east of Sopenah (Little Falls) in bank of Cowlitz River, Lewis County, Sec. 27, T. 11 N., R. 2 W.

Horizon.—Cowlitz formation, Upper Eocene.

GENUS NASSA MARTINI.

NASSA EOCENICA n. sp.

Plate III, Figure 32.

Description.—Shell small fusiform; spire moderately high; whorls eight and convex, last two on apex, smooth, rounded and without ornamentation; upper portion of each whorl surrounded by a deep depression, above which a low collar extends upward to the suture; suture distinct. Surface of shell ornamented by eighteen longitudinal ribs which are very distinct on the spire but faint in the body whorls; they begin at the suture and extend the length of the whorls with the exception of the body whorl where they disappear a short distance below the convex portion; body whorl sculptured by eleven very prominent revolving ribs; alternating with these are eleven less prominent revolving lines on either side of which is a fine but distinct revolving thread. Sculpture similar on the spire. Canal short and fairly strongly

recurved; aperture moderately narrow and tapering towards the end of the canal; inner lip slightly incrusted; outer lip crenulated.

Dimensions.—Altitude 18 mm.; diameter 10 mm.; altitude of spire 6 mm.; angle of spire 57°.

Occurrence.—Very common at Loc. No. 1 (University of Washington Palaeontological Collection) one and one-half miles east of Sopenah (Little Falls) in bank of Cowlitz River, Lewis County, Sec. 27, T. 11 N., R. 2 W.

Horizon.—Cowlitz formation, Upper Eocene.

NASSA PACKARDI n. sp.

Plate III, Figure 34.

Description.—Shell small, short, fusiform; whorls five; suture distinct; body whorl very convex; upper surface below suture broadly grooved. Surface ornamented by twenty-five longitudinal ribs which extend from upper groove to base of whorl; these are crossed by sixteen equally spaced revolving ribs. Aperture broad, elliptical and evenly rounded. Canal short and not strongly recurved. Columella strongly incrusted.

Dimensions.—Altitude 15 mm.; diameter 9 mm.; altitude of spire 5 mm.; angle of spire 65°.

Occurrence.—At Loc. No. 1 (University of Washington Palaeontological Collection) one and one-half miles east of Sopenah (Little Falls) in bank of Cowlitz River, Lewis County, Sec. 27, T. 11 N., R. 2 W.

Horizon.—Cowlitz formation, Upper Eocene.

GENUS CHRYSODOMUS SWAINS.

CHRYSODOMUS CLALLAMENSIS n. sp.

Plate XV, Figure 136.

Description.—Shell of moderate size, sub-fusiform; spire moderately high; whorls seven, convex; body whorl regularly convex with very faint angulation a short distance below the suture; suture distinct and impressed. Surface ornamented with thirty very low revolving ribs between each pair of which

there is a very fine revolving thread; about twenty-five faint longitudinal ribs are present. This sculpture is present on all the whorls. Canal of medium length and somewhat bent backwards; inner lip incrusted; outer lip somewhat thickened; aperture broad.

Dimensions.—Altitude 37 mm.; diameter 18 mm.; altitude of spire 16 mm.; angle of spire 45°.

Occurrence.—At Loc. No. 105 (University of Washington Palaeontological Collection) at Slip Point just east of Clallam Bay, Clallam County.

Horizon.—Upper part of Lower Miocene.

GENUS HEMIFUSUS SWAINSON.

HEMIFUSUS SOPENAHENSIS n. sp.

Plate I, Figures 2, 3.

Description.—Shell large, robust, moderately elongate and convex; whorls seven to eight and very convex; suture undulating and fairly distinct; middle three-fifths of each whorl convex; upper part concave, then vertical to the suture; lower part slightly concave; upper or seventh whorl of shell smooth and rounded; other whorls highly ornamented. Surface ornamented by ten very prominent longitudinal ribs which extend over almost the whole shell, except a small area just below the suture; at the extreme lower portion of the body whorl they become somewhat obscure. Surface of body whorl up as far as the upper portion of the convex part sculptured by fifteen very prominent revolving ribs. Alternating with these is a less prominent rib, on either side of which is a fine raised thread. This sculpture extends to the end of the canal. Surface of the whorl above upper end of convex portion is sculptured by seven revolving ribs alternating with fine threads. At the intersection of the revolving lines and longitudinal ribs on the convex part of the shell, distinct, short spines are developed; sculpture of whorls on spire similar. Canal short and bent to the left. Anterior sinus fairly deep; inner lip smooth and calloused; outer lip smooth;

aperture large, semi-elliptical and extending to the end of the canal.

Dimensions.—Altitude 45 mm.; diameter 22 mm.; altitude of spire 15 mm.; angle of spire 45°.

Notes.—Exceedingly well preserved.

Occurrence.—Very common at Loc. No. 1 (University of Washington Palaeontological Collection) one and one-half miles east of Sopenah (Little Falls) in bank of Cowlitz River, Lewis County, Sec. 27, T. 11 N., R. 2 W.

Horizon.—Cowlitz formation, Upper Eocene.

Hemifusus cowlitzensis n. sp.

Plate I, Figures 1, 4.

Description.—Shell unequally fusiform, spire low, whorls five, the last always tri-carnate, the others with rounded carinae. Last two whorls forming the apex smooth and rounded. Whorls convex; portions between the carinae concave; that above the upper carina nearly straight and sloping up at a low angle to the suture; that below the lower carina very slightly concave. Surface of body whorl sculptured by three carinae which are crossed by twenty-six longitudinal ribs extending from the suture to the extreme lower end of the shell. Their intersections are marked by nodes or tubercles. Between the longitudinal ribs are lines of growth. Between the carinae above and below them are numerous distinct revolving threads; eight above the upper carina, eight between upper and middle carinae, seven between the middle and lower, and twenty-three on the surface below the lowest carina. On the lower surface every alternating thread is a little more distinct. Aperture generally broad and extending to the end of the canal; canal much longer than spire and slightly curved outwards; inner lip smooth and somewhat calloused; outer lip thin.

Dimensions.—Altitude 40 mm. and 32 mm.; diameter 22 mm. and 18 mm.; altitude of spire 5 mm and 3 mm.; angle of spire 65° and 61°.

Notes.—This species resembles somewhat *Fusu horni* Gabb but has a greater number of longitudinal ribs. Specimens are abundant and as well preserved as though living.

Occurrence.—Very common at Loc. No. 1 (University of Washington Palaeontological Collection) one and one-half miles east of Sopenah (Little Falls) in bank of Cowlitz River, Lewis County, Sec. 27, T. 11 N., R. 2 W.

Horizon.—Cowlitz formation, Upper Eocene.

HEMIFUSUS LEWISIANA n. sp.

Plate I, Figure 9.

Description.—Shell of moderate size, elongate and fusiform; spire high and acute; whorls seven and rounded; upper two smooth with no ornamentation; body whorl convex; whorls of spire slightly convex and relatively long; suture distinct. Surface ornamented by eighteen fairly distinct longitudinal ribs which are more prominent on the spire than on body whorl; they become indistinct on lower surface of body whorl; these are crossed by nineteen distinct flat topped revolving ribs alternating with nineteen fine revolving threads. Aperture moderately large, relatively narrow; canal short and slightly deflected outwards; two indistinct plications are generally present; inner lip moderately calloused; outer lip thick and crenulated within.

Dimensions.—Altitude 25 mm.; diameter 10 mm.; altitude of spire 10 mm.; angle of spire 37°.

Occurrence.—At Loc. No. 1 (University of Washington Palaeontological Collection) one and one-half miles east of Sopenah (Little Falls) in bank of Cowlitz River, Lewis County, Sec. 27, T. 11 N., R. 2 W.

Horizon.—Cowlitz formation, Upper Eocene.

HEMIFUSUS WASHINGTONIANA n. sp.

Plate II, Figures 11, 12.

Description.—Shell of moderate size and fusiform; whorls eight, convex, and slightly angulated; body whorl concave above

angle; suture distinct and sinuous. Surface ornamented with thirteen longitudinal ribs which are most prominent on the middle portion of whorl. These are crossed by twenty distinct revolving ribs which are set with spiny nodes at the intersections with the longitudinal ribs. Alternating with each revolving rib is a revolving thread. Aperture moderately broad, somewhat elongated and continuing to end of canal. Canal straight and moderately long; inner lip smooth and calloused; outer lip thin.

Dimensions.—Altitude 29 mm.; diameter 15 mm.; altitude of spire 10 mm.; angle of spire 57°.

Occurrence.—At Loc. No. 1 (University of Washington Palaeontological Collection) one and one-half miles east of Sopenah (Little Falls) in bank of Cowlitz River, Lewis County, Sec. 27, T. 11 N., R. 2 W.

Horizon.—Cowlitz formation, Upper Eocene.

HEMIFUSUS TEJONENSIS n. sp.

Description.—Shell of moderate size, robust; spire moderately low; whorls seven and very slightly convex; upper portion of body whorl very slightly concave; suture not very distinct and slightly sinuous. Surface ornamented by fifteen fairly well developed longitudinal ribs which are most prominent on middle portion of whorl. They are not present on the extreme upper and lower portions. These ribs are crossed by eighteen prominent revolving ribs, alternating with as many minor revolving threads. Low nodes are present on middle six or seven revolving ribs at the intersections with the longitudinal ribs. Aperture moderately broad, acute at posterior and anterior ends; canal straight; inner lip smooth and much calloused; outer lip thin.

Dimensions.—Altitude 28 mm.; diameter 16 mm.; altitude of spire 7 mm.; angle of spire 63°.

Occurrence.—At Loc. No. 1 (University of Washington Palaeontological Collection) one and one-half miles east of Sopenah (Little Falls) in bank of Cowlitz River, Lewis County, Sec. 27, T. 11 N., R. 2 W.

Horizon.—Cowlitz formation, Upper Eocene.

GENUS BRACHYSPHINGUS GABB.

BRACHYSPHINGUS CLARKI n. sp.

Plate IV, Figure 38, and Plate VI, Figure 57.

Description.—Shell of moderate length, heavy and thick; spire moderately high (never as low as in *B. sinuatus* Gabb); body whorl very large; whorls of spire five and distinct (never hidden); suture linear and distinct; body whorl moderately convex with often a faint depression on the upper portion just below the suture. Surface smooth except for well developed sinuous lines of growth; no revolving ribs are present on any specimens examined. Aperture broad and long, and very deeply notched at the anterior end; a prominent fold extends from the upper part of this notch around lower part of whorl; inner lip thickly incrusted; outer lip thin.

Dimensions.—Altitude 34 mm.; diameter 18 mm.; altitude of spire 8 mm.; angle of spire 65°.

Locality.—At Loc. No. 5 (University of Washington Palaeontological Collection).

Horizon.—Tejon formation, Upper Eocene.

GENUS MUREX LINNAEUS.

MUREX SOPENAHENSIS n. sp.

Plate I, Figure 8.

Description.—Shell moderately large, heavy and somewhat spinose; spire moderately high; whorls nine and angular; body whorl with revolving angle at base of upper third of whorl; surface above this angle straight to slightly convex; surface below angle slightly convex. Surface sculptured by eight prominent revolving ribs below the angle and between each two there are three minor revolving threads; above the angle there are ten small, but well developed revolving threads. Varices are present but weakly developed. On the angle at the intersections with the varices are flattened or spinose nodes; sometimes these are present on the varices a short distance below the angle. Angle formed by upper and lower surfaces of the body whorl is 88°. Aperture broad and oval and narrowing a short distance from

anterior end of canal. Canal long and bent; inner lip smooth and calloused; outer lip moderately thin.

Dimensions.—Altitude to broken end 28 mm.; diameter 19 mm.; altitude of spire 11 mm.; angle of spire 63°.

Occurrence.—Common at Loc. No. 1 (University of Washington Palaeontological Collection) one and one-half miles east of Sopenah (Little Falls) in bank of Cowlitz River, Lewis County, Sec. 27, T. 11 N., R. 2 W.

Horizon.—Cowlitz formation, Upper Eocene.

Murex cowlitzensis n. sp.

Plate I, Figure 7.

Description.—Shell of moderate size, heavy and spinous; spire short; whorls six, angulated and with six varices continuous on all whorls; angle situated on upper third of body whorl; surface below angle very slightly concave; surface above straight and sloping upward at a low angle; angle between upper and lower surfaces of whorl 78°; suture impressed and distinct. Whorls of spire flattened. Surface ornamented with fifteen revolving ribs each of which is separated from the adjoining one by two very small closely set revolving striae. At the intersection of angle and varices large rough spines are developed. Aperture broad, oval, nearly closed at anterior end and extending nearly to the end of canal. Canal long, heavy and bent; inner lip heavily calloused; outer lip moderately thick.

Dimensions.—Altitude 40 mm.; diameter 28 mm.; altitude of spire 11 mm.; angle of spire 80°.

Occurrence.—At Loc. No. 1 (University of Washington Palaeontological Collection) one and one-half miles east of Sopenah (Little Falls) in bank of Cowlitz River, Lewis County, Sec. 27, T. 11 N., R. 2 W.

Horizon.—Cowlitz formation, Upper Eocene.

GENUS FUSUS LAMARCK.

FUSUS WASHINGTONIANA n. sp.

Plate II, Figure 10.

Description.—Shell moderately small; spire pagodaform and elongate; whorls eleven and very sharply angulated; body whorl with angle at lower half of middle third of surface. Surface above angle straight and sloping upwards at an angle of 45°; lower surface straight and sloping downwards making an angle with the upper surface of 100°; lower surface of whorls of spire straight and nearly horizontal. Surface ornamented with thirteen longitudinal ribs which are limited to flattened nodes on the angle and gradually disappear toward the suture; twenty-eight equally spaced revolving ribs are present. Suture distinct and undulating. Longitudinal lines of growth well developed. Canal long and straight; inner lip incrusted; outer lip thin.

Dimensions.—Altitude, apex to broken end of spire 25 mm.; diameter 13 mm.; altitude of spire 15 mm.; angle of spire 50°.

Notes.—This species is very well preserved and resembles very closely *F. pagodaformis* of the Clayborne of Alabama.

Occurrence.—At Loc. No. 1 (University of Washington Palaeontological Collection) one and one-half miles east of Sopenah (Little Falls) in bank of Cowlitz River, Lewis County, Sec. 27, T. 11 N., R. 2 W.

Horizon.—Cowlitz formation, Upper Eocene.

FUSUS DICKERSONI n. sp.

Plate III, Figure 29, and Plate XIV, Figure 124.

Description.—Shell elongated, slender and fusiform; spire longer than aperture; whorls eleven, very slightly convex; suture very distinct, impressed and linear. Surface ornamented with fifteen prominent longitudinal ribs which extend over all the whorls; these are crossed by twenty-two revolving ribs on the body whorl; between these ribs are broad, deep, flat-bottomed interspaces. Aperture narrow; inner lip highly incrusted; outer lip thin. Canal moderately long.

Dimensions.—Altitude 45 mm.; diameter 9 mm.; altitude of spire 28 mm.; angle of spire 23°.

Occurrence.—At Loc. No. 1 (University of Washington Palaeontological Collection) one and one-half miles east of Sopenah (Little Falls) in bank of Cowlitz River, Lewis County, Sec. 27, T. 11 N., R. 2 W.

Horizon.—Cowlitz formation, Upper Eocene.

Fusus lewisensis n. sp.

Plate III, Figure 33.

Description.—Shell moderate in size, fusiform; whorls eight to nine and somewhat angulated; body whorl convex in middle portion; nearly straight above and sloping up steeply to the suture. Suture distinct and slightly sinuous. Surface ornamented by eleven not very distinct longitudinal ribs; these are most prominent on the convex portion of the surface; above the angle they are faint and disappear before reaching the suture; they are entirely absent from lower portion of body whorl; they are present on all whorls of spire. The longitudinal ribs are crossed by fifteen distinct revolving ribs, four of which on the convex part of whorl carry sharp spinose nodes; between each of the prominent ribs there are four or five less distinct revolving threads with broad deep interspaces. Aperture moderately broad; inner lip smooth and slightly calloused; outer lip smooth; canal moderately long and bent outwards.

Dimensions.—Altitude 28 mm.; diameter 13 mm.; altitude of spire 8 mm.; angle of spire 49°.

Occurrence.—At Loc. No. 1 (University of Washington Palaeontological Collection) one and one-half miles east of Sopenah (Little Falls) in bank of Cowlitz River, Lewis County, Sec. 27, T. 11 N., R. 2 W.

Horizon.—Cowlitz formation, Upper Eocene.

GENUS FASCIOLARIA LAMARCK.

FASCIOLARIA WASHINGTONIANA n. sp.

Plate I, Figure 5.

Description.—Shell moderately large, robust and turreted; spire high; whorls eight, angulated; angle situated at lower part of upper third of body whorl, concave above and concave to flat below. Surface ornamented by thirteen very distinct revolving ribs confined almost entirely to the angulated area where they exist as short spine-like nodes; twenty-five revolving ribs are present each of which is separated from the one next to it by a very small revolving thread; they all appear beaded, due to the intersections with the prominent lines of growth. Lines of growth are sinuous and above the angle curved to the right in accordance with the posterior sinus. Suture distinct and sinuous. Canal very narrow, angle in outer lip; columella slightly bent in advance with two very faint plications; inner lip calloused; outer lip thin.

Dimensions.—Altitude 44 mm.; diameter 22 mm.; altitude of spire 8 mm.; angle of spire 49°.

Occurrence.—At Loc. No. 1 (University of Washington Palaeontological Collection) one and one-half miles east of Sopenah (Little Falls) in bank of Cowlitz River, Lewis County, Sec. 27, T. 11 N., R. 2 W.

Horizon.—Cowlitz formation, Upper Eocene.

GENUS MITRA LAMARCK.

MITRA WASHINGTONIANA n. sp.

Plate II, Figure 16.

Description.—Shell very small, sub-fusiform and smooth; spire moderately long; whorls seven and very convex; body whorl regularly convex; suture distinct and moderately deep; surface sculptured by fine microscopic revolving threads and very fine closely set lines of growth. This sculpture is very indistinct with the unaided eye but can clearly be made out with a hand lens; the upper surface of each whorl immediately below the suture is set with minute, closely-spaced longitudinal

ribs which disappear a short distance below on the whorl. Aperture narrow, elongate, continuing but becoming very narrow at end of canal; canal short; inner lip somewhat incrusted and set with four oblique folds, the posterior of which are the larger.

Dimensions.—Altitude 12 mm.; diameter 5.5 mm.; altitude of spire 4.5 mm.; angle of spire 58°.

Occurrence.—Common at Loc. No. 1 (University of Washington Palaeontological Collection) one and one-half miles east of Sopenah (Little Falls) in bank of Cowlitz River, Lewis County.

Horizon.—Cowlitz formation, Upper Eocene.

GENUS ANCILLARIA LAMARCK.

ANCILLARIA BRETZI n. sp.

Plate II, Figure 21.

Description.—Shell small, robust; spire high; whorls seven, convex; suture distinct; just below the suture there is a small band formed by a grooving of the upper margin of whorl. Surface of shell sculptured with twenty-five longitudinal transverse ribs extending over the entire whorl from suture to plications; between each rib are five fine longitudinal threads; no revolving lines are present. Aperture broad; posterior end narrowing; anterior very wide; inner lip somewhat incrusted; columella with four plications; outer lip thin; anterior sinus deep.

Dimensions.—Altitude 15 mm.; diameter 8 mm.; altitude of spire 4 mm.; angle of spire 52°.

Occurrence.—At Loc. No. 1 (University of Washington Palaeontological Collection) one and one-half miles east of Sopenah (Little Falls) in bank of Cowlitz River, Lewis County.

Horizon.—Cowlitz formation, Upper Eocene.

GENUS SURCULA H. AND A. ADAMS.

SURCULA COWLITZENSIS n. sp.

Plate III, Figures 30, 36, and Plate IX, Figure 86.

Description.—Shell slender, elongate, biconical and fusiform; length of spire equal to that of canal; whorls eleven and sharply

angulated; suture distinct, impressed and linear; surface below angle slightly convex, that above distinctly concave; surface of body whorl ornamented with fifteen longitudinal ribs which extend over whorls of spire; these entirely disappear just above the angle and a short distance below and form conspicuous nodes on the angle; there are sixteen equally spaced revolving ribs from base to angle and between each is a broad flat-bottomed interspace containing a fine revolving thread; in addition there are fine lines of growth which are sinuous and conform to the posterior sinus. Aperture narrow and elongate terminating in a long narrow canal; posterior end with deep sinus; inner lip smooth and incrusted; outer lip thin; canal long and straight.

Dimensions.—Altitude 45 mm.; diameter 7 mm.; altitude of spire 22 mm.; angle of spire 30°.

Occurrence.—At Loc. No. 1 (University of Washington Palaeontological Collection) one and one-half miles east of Sopenah (Little Falls) in bank of Cowlitz River, Lewis County.

Horizon.—Cowlitz formation, Upper Eocene.

GENUS CONUS LINNAEUS.

CONUS COWLITZENSIS n. sp.

Plate II, Figure 20.

Description.—Shell biconical; spire a little over one-fourth of total length; whorls seven and a half to eight, and very sharply angulated; upper two forming the apex are smooth and rounded; angle set with nodes. Body whorl conical below the angle; nearly flat above but sloping close to the suture making the upper surface of each whorl decidedly convex; eighteen very distinct nodes on the angle; these do not continue above or below as ribs; although blunt and rounded they are pointed slightly to the left. Surface marked by forty revolving lines below the angle which are more distinct toward base of whorl; portion of whorl above angle obscurely sculptured by revolving lines. Numerous faint lines of growth are present. Aperture linear and narrow, and extending to end of spire. The spire varies some-

what in length, but the upper surface of whorls are extremely convex.

Dimensions.—Altitude 38 mm.; diameter 15 mm.; altitude of spire 13 mm.; angle of spire 50°; angle of lower part of body whorl 33°.

Occurrence.—Common at Loc. No. 1 (University of Washington Palaeontological Collection) one and one-half miles east of Sopenah (Little Falls) in bank of Cowlitz River, Lewis County.

Horizon.—Cowlitz formation, Upper Eocene.

BRACHIOPODA.

GENUS RHYNCONELLA FISCHER.

RHYNCONELLA WASHINGTONIANA n. sp.

Plate V, Figures 44, 45.

Description.—Shell sub-circular medium size, thin and very slightly longer than wide; hinge line narrow and situated at middle of shell; dorsal valve evenly convex, sub-circular with no trace of medial fold; ventral valve with same convexity as dorsal; sinus distinct; margin sloping down at an angle of 40° from beak; base arcuate; beak prominent, incurved. Sculptured with about thirty radiating ribs, many of which are dichotomous; these are crossed by numerous concentric lines of growth; medial groove fairly distinct, but not deep; more pronounced towards basal margin.

Dimensions.—Ventral valve, altitude 20 mm.; longitude 17 mm.; thickness 2.5 mm. Dorsal valve, altitude 18 mm.; longitude 18 mm.; thickness 2.5 mm.

Occurrence.—At Loc. No. 1 (University of Washington Palaeontological Collection) one and one-half miles east of Sopenah (Little Falls) in bank of Cowlitz River, Lewis County.

Horizon.—Cowlitz formation, Upper Eocene.

MIOCENE SPECIES.

PELECYPODA.

GENUS LEDA SCHUMACHER.

LEDA CHEHALISENSIS n. sp.

Plate XII, Figures 104, 105.

Description.—Shell small, moderately convex, equivalve and nearly equilateral; beaks slightly elevated and curved forwards; lunule very large; cordate elongate and fairly deeply impressed; escutcheon long and narrow; anterior margin of shell concave, at first sloping steeply for a short distance from the beaks, and then straight to the anterior end; anterior end bluntly truncated upward; base broadly rounded; posterior margin very slightly convex and sloping downwards at a low angle; posterior end acutely rounded. Sculptured by equally spaced closely set concentric ribs with deeply grooved interspaces equal in width to the ribs.

Dimensions.—Altitude 10 mm.; longitude 15 mm.; thickness 3.5 mm.

Occurrence.—At Loc. No. 63, in northwest quarter of Section 28, T. 17 N., R. 17 W.

Horizon.—Chehalis formation, upper part of Lower Miocene.

GENUS YOLDIA MOLLER.

YOLDIA SAMMAMISHENSIS n. sp.

Plate XIII, Figure 106.

Description.—Shell thin, moderately compressed, equivalve, slightly inequilateral. Anterior end slightly longer than posterior; anterior margin slopes slightly upwards from the beak, then bends rather sharply, passes broadly around the anterior end and slopes at 45° to the base. Basal margin straight for some distance and then slopes upward at 20° and finally is obliquely truncated upwards at the posterior end; posterior margin slopes down 45° from beak and then extends at an angle of 15° to the posterior end; posterior end slightly bent. Beaks low and directed posteriorly. Surface ornamented by moderately coarse to fine evenly spaced concentric ridges. There

are nineteen posterior hinge teeth, anterior number undeterminable.

Dimensions.—Longitude 60 mm.; altitude 32 mm.; diameter 9 mm.

Occurrence.—Occurs in the basal Miocene overlying the Puget [Eocene] sandstones, two miles northeast of Issaquah, King County.

Horizon.—Blakeley formation, Lower Miocene.

GENUS PECTEN MULLER.

PECTEN PORTERENSIS n. sp.

Plate VIII, Figures 70, 72.

Description.—Shell slightly higher than long, inequivalve, equilateral. Margins somewhat serrate, base rounded; sides sloping above; sides considerably concave above, the posterior being more so than the anterior; right valve with twenty nearly equal slightly rounded radiating ribs, which are always dichotomous and often trichotomous, and begin so about 40 mm. from the beak; interspaces unequal, nearly twice as broad as the ribs and always ornamented by at least one auxiliary rib which begins near the beak and often attains at least one-half the size of the regular ribs. The four anterior interradials are strongly imbricated or crenulated. Whole surface ornamented by very fine concentric striations; ears subequal; anterior ear with six radials and moderately fine concentric lines; byssal notch very pronounced; posterior ear with eight radials, strongly crenulated and truncated by a convex curve.

Dimensions.—Longitude 86 mm.; altitude 100 mm.; diameter 23 mm.

Occurrence.—In the sandstones overlying the basalt, one mile west of Oakville, Chehalis County, in Northern Pacific railroad cut.

Horizon.—Blakeley formation, Lower Miocene.

PECTEN ALOCKAMANENSIS n. sp.

Plate XIII, Figure 115.

Description.—Shell small, much higher than long, equivalve, equilateral; sides straight and sloping regularly at an angle of 50° from the beak; base regularly rounded; left valve has 13 or 14 equally rounded ribs which are not sulcated; interspaces are flat-bottomed and slightly wider than the radiating ribs. Surface ornamented with fine incremental lines; anterior ear about one-third longer than posterior; byssal area moderately deep; posterior ear truncated and both ornamented by fine concentric lines.

Dimensions.—Longitude 18 mm.; altitude 24 mm.; diameter 3 mm.

Occurrence.—Common at Loc. No. 54 (University of Washington Palaeontological Collection) near the head of Alockaman River, Cowlitz County, in Sec. 2, T. 9 N., R. 5 W.

Horizon.—Near base of Wahkiakum formation, Lower Miocene.

GENUS MYTILUS LINNAEUS.

MYTILUS SAMMAMISHENSIS n. sp.

Plate XIII, Figure 111.

Description.—Shell small, moderately thick, elongate; left valve larger than right; beaks small, terminal; anterior margin nearly straight with an upward slope for some distance from the beaks and then broadly rounded to the posterior end; basal margin nearly straight but curving slightly toward the beak. Shell thickest about one-third distance up from the base, sloping sharply to the base and gradually to the anterior margin. Surface ornamented by numerous faint concentric striations and a few irregular lines of growth. Still possesses dark coloration.

Dimensions.—Longitude 30 mm.; altitude 17 mm.; diameter 8 mm.

Occurrence.—Occurs abundantly two miles northeast of Issaquah, King County, in the lower part of the Blakeley formation. Loc. No. —— (University of Washington Palaeontological Collection).

Horizon.—Lower Blakeley formation, Lower Miocene.

MYTILUS STILLAGUAMISHENSIS n. sp.

Description.—Shell large, thick, elongated; beaks terminal and not prominent; anterior margin broadly arcuate, basal margin nearly straight but in some specimens slightly concave; posterior end sharply rounded; greatest thickness of the shell about one-fourth the distance up from the base. Surface sloping steeply to the base and gradually to the anterior margin; surface ornamented by faint concentric lines of growth.

Dimensions.—Longitude 90 mm.; altitude 37 mm.; diameter 28 mm.

Occurrence.—Occurs abundantly in the sandstones in the banks of the Stillaguamish River about four miles northwest of the town of Granite Falls, Snohomish County.

Horizon.—Blakeley formation, Lower Miocene.

MYTILUS SNOHOMISHENSIS n. sp.

Plate XIII, Figure 110.

Description.—Shell small, moderately thick, elongate, narrow; beaks terminal and small; dorsal slope arcuate with a pronounced angle about one-third distance from the beak; base straight or very slightly concave; posterior end sharply rounded. Surface convex, sloping at a lower angle to the dorsal area and steeply to the base; ornamented by fine concentric striae and irregular lines of growth.

Dimensions.—Longitude 33 mm.; altitude 15 mm.; diameter 7 mm.

Occurrence.—Common at Fiddler's Bluff, three miles south of Snohomish City, Snohomish County. Loc. No. 228 (University of Washington Palaeontological Collection).

Horizon.—Blakeley formation, Lower Miocene.

GENUS VENERICARDIA LAMARCK.

VENERICARDIA CHEHALISENSIS n. sp.

Plate XII, Figures 101, 102, and Plate XV, Figures 133, 137.

Description.—Shell robust, thick, sub-triangular, equivalve and inequilateral; beaks not especially prominent for the genus

with anteriorly recurved umbones; lunule very small, cordate; escutcheon absent; anterior margin very slightly concave and slopes at about 45° to anterior end where it rounds and merges into the base, which slopes at an angle of 40° to the posterior end, when it curves sharply upwards; posterior margin slopes gently at first from the beak for a short distance and then drops decidedly to the posterior end. Surface ornamented by twenty equally spaced radiating rounded, fairly well marked ribs; the interspaces are not deep and are nearly as wide as the ribs. These are crossed by numerous well developed concentric lines of growth. Hinge plate large; muscular scars very pronounced; palial line distinct and about one-sixth the distance of shell from margin.

Dimensions.—Longitude 23 mm.; altitude 28 mm.; diameter 10 mm.

Occurrence.—One of the most common species in the Chehalis formation. Two miles southwest of Montesano.

Horizon.—Chehalis formation, upper part of Lower Miocene.

GENUS CHIONE MEGERLE.

CHIONE CHEHALISENSIS n. sp.

Plate VIII, Figure 71.

Description.—Shell large, sub-trigonal, very inequilateral, very thick, equivalve; beaks elevated, situated at the anterior fourth of the shell, medium sized and pointing anteriorly; lunule short, cordate and strongly impressed; escutcheon large and elongate but not very well defined; posterior margin rounded and gradually sloping from the beaks until it becomes vertical; it is sharply flexed where it joins the basal margin. Basal margin evenly arcuate and sharply inclined upward to the anterior end. Anterior end slopes down abruptly from the beaks and then slopes about 40° to the anterior end; posterior portion of shell curved around broadly so as to form an angle of 110° bringing the real posterior margin 10 mm. anterior to the axis of the fold. Surface sculptured with about eighty rounded radial ribs which show up prominently as the outer surface of the shell

becomes worn. The anterior twenty and the posterior twelve ribs are very fine and closely set, the medial forty-eight are about 1 mm. broad and 1 mm. apart, and more pronounced toward the base than towards the beak. These are crossed by numerous irregularly spaced crenate concentric lamellae.

Dimensions.—Longitude 65 mm.; altitude 65 mm.; diameter 33 mm.

Notes.—This species occurs with *Chione securis*, but differs from it in its sub-trigonal form, pronounced in-bending of posterior end, thickness and escutcheon.

Occurrence.—Common at Loc. No. 46 (University of Washington Palaeontological Collection) about one-half way between Montesano and Aberdeen on the south side of the Chehalis River, in Chehalis County.

Horizon.—Montesano formation, lower part of Upper Miocene.

CHIONE MONTESANOENSIS n. sp.

Plate XII, Figures 95, 97, 103.

Description.—Shell small, sub-angular to rounded, moderately thick, inequilateral, equivalve; lunule cordate, concentrically striated, projecting along the medial line and surrounded by a moderately deep groove. No escutcheon observed; beaks moderately high. Posterior dorsal margin nearly straight excepting just behind the beak where it is slightly concave. It slopes downwards at an angle of 45° and then drops nearly vertical and merges into the evenly rounded base; anterior margin slopes steeply from the beak and then flares out and is slightly truncated at the anterior end, where it gently curves and merges into the basal margin. Surface sculptured by numerous concentric ridges evenly spaced and nearly equally developed from the beak to the base; these ridges are crossed by twenty-eight prominent radiating ribs which are equally developed from the beak to the base; at the posterior end of the shell these ribs are narrow; in the center and on the posterior portion of the shell they are broad with deep narrow grooves

between them. The beak is sculptured as well as the surface of the shell. Hinge with three cardinal teeth and one obscure posterior lateral; muscular scars prominent; palial line distinct with a small triangular sinus only extending into the shell about 4 mm.

Dimensions.—Longitude 25 mm.; altitude 18 mm.; diameter 8 mm.

Notes.—C. *Montesanoensis* is most closely related to C. *bisculpta* Dall, but may be distinguished from it by the difference in the sculpture which does not vary in a large number of unworn specimens, in the smaller size of the palial sinus and in the greater altitude compared with length. It is common in the conglomerate of the Montesano formation.

Occurrence.—Occurs abundantly at Loc. No. 68 (University of Washington Palaeontological Collection) in the Montesano conglomerate on Sylvia Creek about six miles north of Montesano, Chehalis County.

Horizon.—Montesano formation, lower part of Upper Miocene.

Chione cathcartensis n. sp.

Plate X, Figure 79.

Description.—Shell of moderate size, subtriangular, thick and very inequilateral; beaks situated a distance of one-sixth of the length of the shell from the anterior end, and strongly inclined forwards; anterior margin slightly concave and sloping downwards at an angle of 65°; anterior end very acutely rounded; posterior margin arcuate from beak to posterior end, where it forms a sharp angle with the base which slopes up decidedly to the anterior end and gradually to the posterior; sharp angular ridge extending from beak to posterior end and situated just in front of posterior margin; surface sculptured by numerous well developed roughened concentric lines of growth; lunule moderately large but not much impressed.

Dimensions.—Altitude 33 mm.; longitude 44 mm.; thickness 10 mm.

Occurrence.—At Loc. N. 228 (University of Washington Palaeontological Collection) at Fiddler Bluff, Cathcart, in Northern Pacific Railway cut.

Horizon.—Blakeley formation, Lower Miocene.

GENUS MARCIA ADAMS.

MARCIA OREGONENSIS CONRAD.

Plate XII, Figure 96.

This species is very common in the Lincoln and Blakeley formations. It varies somewhat in shape but the specimen figured in this report is most characteristic and was collected from the Lincoln shales in southern Thurston County. It ranges up into the Wahkiakum and Chehalis formations but is not especially common.

GENUS TELLINA LINNAEUS.

TELLINA MERRIAMI n. sp.

Plates IX, X, XIII, Figures 74, 81.

Description.—Shell elongate, attenuated posteriorly, compressed slightly, inequivalve and nearly equilateral; surface smooth; beaks low, curved slightly forward; anterior margin very slightly convex and sloping at an angle of 15° which increases to 30° near the anterior end, which terminates in a sharp angle and is evenly rounded; posterior margin slopes from beak at an angle of about 40° with a very slight convexity midway between beak and posterior end; posterior end abruptly truncated; basal margin a broad regularly curved line excepting just anterior to the posterior end, when it is very slightly concave; posterior surface of right valve flexed, making an angle of about 125° and forming a ridge from the beak to posterior extremity; an obscure groove extends from beak to posterior end of basal margin. Surface sculptured by fine concentric incremental lines and near the margin a few prominent lines of interrupted growth.

Dimensions.—Longitude 48 mm.; altitude 28 mm.; diameter 7 mm.

Notes.—*T. merriami* is very close to *T. kincaidi* but may be distinguished by the more central position of the beaks, the more attenuated posterior end and the more pronounced folding of the posterior margin. It occurs with *T. kincaidi* in the conglomerate of the Montesano formation.

Occurrence.—Occurs at Loc. No. 68 (University of Washington Palaeontological Collection) in the basal conglomerate of the Montesano formation on Sylvia Creek, six miles north of the town of Montesano, in Chehalis County.

Horizon.—Montesano formation, lower part of Upper Miocene.

TELLINA KINCAIDI n. sp.

Plate X, Figure 82.

Description.—Shell elongate, sub-oval, moderately narrow, compressed, inequilateral, slightly inequivalve, attenuated anteriorly; beaks low and situated about one-third the distance from the posterior end of shell. Anterior dorsal margin of shell nearly straight and sloping downward to anterior end of shell at an angle of about 15°. At the anterior end it is sharply angulated and sharply curved to the basal margin which is nearly straight except near posterior end, where it is slightly incurved, due to the minor flexing of the valve. Posterior margin is slightly convex and slopes at an angle of 65° from beak to posterior end of shell where it forms a sharp angle of 60° with the base. Posterior margin sharply bent inwards forming a prominent ridge from beak to base; just anterior to this ridge is an obscure groove more prominent near base. Surface sculptured by numerous fine concentric incremental lines irregularly spaced and occasional lines of growth.

Dimensions.—Longitude 52 mm.; latitude 30 mm.; diameter 7 mm.

Notes.—This form is common in the conglomerate at the base of the Montesano formation and is generally fairly well preserved. It is named in honor of Prof. Trevor Kincaid of the Department of Zoology at the University of Washington.

Occurrence.—Occurs at Loc. No. 68 (University of Washington Palaeontological Collection) in the basal conglomerate of the Montesano formation on Sylvia Creek, six miles north of the town of Montesano, in Chehalis County.

Horizon.—Montesano formation, lower part of Upper Miocene.

GENUS MACOMA LEACH.

MACOMA MONTESANOENSIS n. sp.

Plate X, Figure 80.

Description.—Shell large, sub-oval to rounded triangular, inequilateral, slightly inequivalve; valves moderately convex, concentrically sculptured; beaks low, small, situated nearly medial, but in some specimens slightly posterior to middle. The anterior dorsal margin slopes gently at an angle of about 15° for a short distance, then curves more steeply; anterior end evenly rounded; posterior dorsal margin very slightly concave, sloping at an angle of 45° to the posterior end where it is sharply truncated; ventral margin regularly curved. On the right valve a sharp ridge, forming an angle of 75° to 80° extends from the beak to the posterior extremity; immediately in front of this there is a very slight obscure fold more noticeable near the margin. A very faint ridge is noticeable along the anterior margin. Surface sculptured by numerous impressed incremental lines somewhat irregularly distributed. Interior inaccessible.

Dimensions.—Longitude 68 mm.; altitude 50 mm.; diameter of right valve 10 mm.

Notes.—*M. montesanoensis* resembles *M. piercei* Arnold, but can be distinguished from it by its more trigonal shape, the greater slope of the posterior margin, the convexity of the posterior margin, the more posterior position of the beak and the sculpture. It is fairly abundant in a fine conglomerate at the base of the Montesano formation on Slyvia Creek, six miles north of the town of Montesano in Chehalis County. It has been found only at Locality No. 68 (University of Washington Palaeontological Collection).

Horizon.—Montesano formation, Upper Miocene.

Macoma snohomishensis n. sp.

Plate XIII, Figure 109.

Description.—Shell small, thin, decidedly inequilateral, slightly inequivalve, attenuated posteriorly. Surface smooth and sculptured with fine concentric lines; beaks small, low and situated near the anterior end; posterior margin straight and slopes at an angle of 15°; posterior end evenly rounded; basal margin nearly straight. Anterior margin short and slopes down 45° from the beak and then slopes gradually around the anterior end and merges with the base.

Dimensions.—Longitude 23 mm.; altitude 12 mm.; diameter of entire shell 8 mm. (4 mm. for each valve).

Occurrence.—Common at Fiddler's Bluff, 3 miles south of Snohomish, Snohomish County. Locality No. 228 (University of Washington Palaeontological Collection).

Horizon.—Blakeley formation, Lower Miocene.

Macoma wynootcheensis n. sp.

Plate XV, Figures 128, 129, 130.

Description.—Shell of moderate size, thin, equivalve, inequilateral; beaks small and situated about two-fifths the length of shell from anterior end. Anterior margin slightly concave and sloping downward at an angle of 37°, obliquely truncated at anterior end; base broadly rounded; posterior margin straight and sloping at an angle of 18° to anterior end, which is acutely rounded. Surface sculptured by close set fine concentric lines of growth.

Dimensions.—Altitude 37 mm.; longitude 50 mm.; thickness of both valves 14 mm.

Occurrence.—At Loc. No. 131 (University of Washington Palaeontological Collection) at a point one mile west of the town of Montesano on logging road cut.

Horizon.—Chehalis formation, upper part of Lower Miocene.

GENUS SEMELE SCHUMARCK.

SEMELE MONTESANOENSIS n. sp.

Plate XII, Figures 98, 99.

Description.—Shell medium sized, sub-quadrate, inequilateral, equivalve, and moderately inflated; beaks somewhat prominent, pointing forwards and situated about two-thirds distance from the anterior end. Posterior margin slopes nearly straight at an angle of about 50° from beak to a point about two-thirds the distance up from the base, where it is truncated at the posterior end; base broadly rounded; anterior margin slopes down sharply from the beak for a very short distance and slopes off at a lower angle for about 6 mm. and then passes as a broad curve around the anterior end where it merges with the base. Surface ornamented with well defined concentric lines of growth. Shell material moderately thin and interior of right valve showing cardinal and lateral teeth fairly well developed; palial line distinct.

Dimensions.—Longitude 29 mm.; altitude 24 mm.; diameter 8 mm.

Occurrence.—This species is very common at Loc. No. 68 (University of Washington Palaeontological Collection) on Sylvia Creek, six miles above town of Montesano, Chehalis County.

Horizon.—Montesano formation, Upper Miocene.

SEMELE SYLVIAENSIS n. sp.

Plate XII, Figure 100.

Description.—Shell moderately large, nearly as high as long, sub-equivalve, nearly equilateral, sub-oval and moderately thick; beaks not very prominent and pointing slightly forwards, and situated nearly central. Anterior margin sloping downwards about 45° just in front of beaks and then sloping gradually downwards at 30° to the anterior end, which is truncated and then rounds off into the base. Base regularly rounded; posterior margin slightly convex and sloping about 45° to posterior end,

which is sharply rounded. Surface ornamented by fairly well developed concentric lines of growth.

Dimensions.—Longitude 33 mm.; altitude 29 mm.; diameter 9 mm.

Occurrence.—Common at Loc. No. 68 (University of Washington Palaeontological Collection) in conglomerate on Sylvia Creek, six miles north of Montesano, Chehalis County.

Horizon.—Montesano formation, Upper Miocene.

GENUS PSEUDOCARDIUM GABB.

PSEUDOCARDIUM GABBI REMOND var. ALTUS n. var.

Plate VII, Figure 69.

Description.—This variety is large, somewhat compressed; beaks moderately high but not especially prominent for the genus. Anterior and posterior margins have steep slopes, the latter being more pronounced. The altitude is much greater in proportion to the longitude than in the case of the other varities.

Dimensions.—Longitude 75 mm.; altitude 78 mm.; diameter 30 mm.

Occurrence.—Common in the uppermost Montesano massive sandstone about two miles northwest of Elma, Chehalis County, Loc. No. 61 (University of Washington Palaeontological Collection).

Horizon.—Montesano formation, Upper Miocene.

PSEUDOCARDIUM GABBI REMOND var. ELONGATUS n. var.

Plate X, Figure 78.

Description.—This variety differs from variety *altus* in its relatively greater length and thickness. It might seem best to regard them as the same, but out of a large number of specimens they can be distinctly separated and do not show gradations from one to the other. They occur at a definite horizon in the same formation and can be used for stratigraphic purposes.

Dimensions.—Longitude 73 mm.; altitude 55 mm.; diameter 34 mm.

Occurrence.—Six miles northeast of Satsop, Chehalis County.

Horizon.—Upper Monterey formation, Upper Miocene.

PSEUDOCARDIUM GABBI REMOND var. ROBUSTUM n. var.
Plate VII, Figure 68.

Description.—A line passed from the beak along the outer surface of the shell to the base forms a nearly perfect semicircle; just back of the anterior margin of the shell a prominent ridge occurs on this point; about two thirds distance from the beak is a blunt protuberance or shoulder; a less marked one occurs on the posterior margin.

Dimensions.—Longitude 80 mm.; altitude 70 mm.; diameter 35 mm.

Occurrence.—Two miles northeast of Satsop, Chehalis County.

Horizon.—Montesano formation, Upper Miocene.

PSEUDOCARDIUM GABBI REMOND var. UNDILIFERUM n. var.
Plate IX, Figure 76.

Description.—Shell typically small, anterior margin slightly convex with a slope of 60°; posterior margin nearly straight with slope of 45°; posterior surface of shell undulatory because of broad groove extending from beak to margin. These characters are constant and do not seem to grade into the other varieties. Several hundred specimens from the same locality show these characteristics.

Dimensions.—Longitude 50 mm.; altitude 40 mm.; diameter 20 mm.

Occurrence.—Common in the basal Montesano conglomerate on Sylvia Creek, six miles north of Montesano, Chehalis County, Loc. No. 68 (University of Washington Palaeontological Collection).

Horizon.—Montesano formation, lower part of Upper Miocene.

PSEUDOCARDIUM LANDESI n. sp.
Plate IX, Figure 75.

Description.—Shell thick, equivalve, nearly equilateral; anterior and posterior margins sloping steeply and at about same angle; base evenly rounded; beaks prominent and pointing

slightly forwards; escutcheon narrow but fairly well defined. Surface ornamented with heavy concentric lines of growth; hinge moderately heavy.

Dimensions.—Longitude 45 mm.; altitude 53 mm.; diameter 25 mm.

Occurrence.—Occurs fairly abundant in the conglomerate at the base of the Montesano formation, six miles north of Montesano, Chehalis County, Loc. No. 68 (University of Washington Palaeontological Collection).

Horizon.—Montesano formation, lower part of Upper Miocene.

GENUS CRYPTOMYA CONRAD.

CRYPTOMYA WASHINGTONIANA n. sp.

Plate XIII, Figure 114.

Description.—Shell small, slightly inequilateral, inequivalve, beaks small; posterior margin sloping abruptly for a very short distance and then nearly straight at an angle of 45° until it drops off nearly vertical to the posterior end; base evenly arcuate. Anterior margin straight and slopes at about 20° to the anterior end which is regularly rounded and merges into the base. Surface ornamented by fairly well developed concentric lines of growth.

Dimensions.—Longitude 31 mm.; altitude 24 mm.; diameter 5 mm.

Occurrence.—Common at Loc. No. 68 (University of Washington Palaeontological Collection) on Sylvia Creek, six miles north of Montesano, Chehalis County.

Horizon.—Montesano formation, Upper Miocene.

GASTEROPODA.

GENUS TURRIS BOLTEN.

TURRIS WYNOOTCHEENSIS n. sp.

Plate XI, Figures 87, 88, 89, 94.

Description.—Shell large with eight whorls; each whorl sharply angulated by a carina near the upper portion; surface of body whorl below angle convex, above very concave; it slopes

at a sharp angle from the carina and then just below the suture abruptly bends and extends outward to the suture where it terminates in a very narrow band or cord; the surface of each whorl of the spire below the carina is nearly flat and nearly vertical; the surface above the carina is similar to the body whorl; the carina is crossed with ribs, producing fourteen sharp nodes which entirely disappear on the surface immediately above the carina as well as within 2 mm. below it, except on the whorls of the spire where they extend down to the suture; transverse sculpture consists of numerous spiral threads which are much more pronounced on the surface of the whorl below the carina than above; on body whorl, below carina, there are fourteen evenly spaced major threads; midway between each of these is a less prominent thread and on each side of this a minor thread; above the carina up to the suture the same sculpture prevails, only less prominent; axial sculpture consists of numerous lines of growth conforming to the posterior sinus whose angle is above the carina. Inner lip smooth and calloused; outer lip smooth; aperture moderately broad. Extreme end of canal broken in every specimen but tending to bend slightly outwards. Older specimens relatively more elongate.

Dimensions.—Altitude 35 mm. and 60 mm.; diameter 17 mm. and 25 mm.; elevation of spire 14 mm. and 22 mm. Angle of spire 52° and 38°.

Occurrence.—Common at Loc. No. 31 (University of Washington Palaeontological Collection) in the shales about one mile west of town of Montesano, Chehalis County.

Horizon.—Chehalis formation, upper part of Lower Miocene.

GENUS CHLOROSTOMA SWAINS.

CHLOROSTOMA ARNOLDI n. sp.

Plate VI, Figure 62.

Description.—Shell very small; spire low, whorls five; suture distinct and impressed; body whorl flattened; convex above; sharply angulated and flat below; sculptured by five distinct revolving ribs on upper surface and set with nodes; between these

ribs the interspaces are broad and concave; under surface similarly sculptured.

Dimensions.—Altitude 9 mm.; diameter 13 mm.; altitude of spire 4 mm.; angle of spire 110°.

Locality.—No. 160 (University of Washington Palaeontological Collection) at Porter Bluff, Chehalis County.

Horizon.—Blakeley formation, Lower Miocene.

GENUS CALIOSTOMA SWAINS.

CALIOSTOMA DELAZINENSIS n. sp.

Plate VI, Figures 59, 60, 61, 63.

Description.—Shell small, largest specimens not over 12 mm. in altitude, conical; whorls six, convex; body whorl with upper surface very slightly convex and sloping up to suture at an angle of 45°; lower surface broadly convex and nearly horizontal; sculpture on body whorl with eight prominent revolving ribs above the angle and ten below, all equally spaced; lines of growth fairly well marked; on some specimens these ribs are very slightly nodose, but it is not characteristic. Interspaces concave, smooth and contain no revolving thread. Sculpture of spire similar to body whorl. Suture distinct and impressed; aperture sub-oval; inner lip smooth; outer lip thin.

Dimensions.—Altitude 13 mm.; diameter 20 mm.; altitude of spire 8 mm.; angle of spire 80°.

Locality.—Six miles up Delazine Creek, Chehalis County, in T. 17 N., R. 6 W., Sec. 20. Loc. No. 44 (University of Washington Palaeontological Collection).

Horizon.—Blakeley formation, Lower Miocene.

GENUS TURRITELLA LAMARCK.

TURRITELLA BLAKELEYENSIS n. sp.

Plate XI, Figure 85, and Plate VI, Figures 64, 67.

Description.—Shell elongated; whorls twelve and flattened to slightly concave; suture impressed; just above the suture is one small revolving rib; above that a deep groove; then the surface slopes outwards and upwards forming an angle; on this

angle are one or two large revolving ribs; the remainder of the surface up to the suture is flat to concave and sculptured with five not very distinct revolving ribs; aperture sub-oval.

Dimensions.—Altitude 65 mm.; width of base 16 mm.; angle of spire 14°.

Occurrence.—At Loc. No. 13 (University of Washington Palaeontological Collection) at Restoration Point, Kitsap County, on north side of Point.

Horizon.—Near top of Blakeley formation, Lower Miocene.

TURRITELLA PORTERENSIS n. sp.

Plate XI, Figures 83, 84.

Description.—Shell of moderate size, elongated, sub-conical; whorls ten to twelve, convex; suture impressed; the lower third of each whorl is broadly angulated; there are three revolving ribs on the angulated area; above this convex angulated portion of the whorl the surface slopes decidedly upwards; it is flat to slightly concave; near the suture the upper portion of whorls become decidedly impressed; at the base of each whorl is a deep wide unsculptured groove; aperture ovoid, broadly rounded below; inner lip incrusted; outer lip simple.

Dimensions.—Altitude 34 mm.; width of body whorl 10.5 mm.; angle of spire 19°.

Occurrence.—Very common at Loc. No. 160 (University of Washington Palaeontological Collection) in the bluff along Northern Pacific Railroad track at Porter, Chehalis County.

Horizon.—Blakeley formation, Lower Miocene.

GENUS GYRINEUM LINK.

GYRINEUM SYLVIAENSIS n. sp.,

Plate XIV, Figure 126.

Description.—Shell large, moderately elongated, with six rounded whorls; suture distinct; four continuous rounded lateral varices, which are very distinct, on the body whorl and the first whorl of the spire; on the remaining whorls they are obscure: between each of the varices there are four distinct broad rounded

of the remaining whorls has its upper portion terminating in a collar set with nodes agreeing in number with those on the body of the whorl; body whorl convex in center, straight or very slightly concave above the center and just below the collar. Same true on lower two whorls of spire. Spire moderately low; on the surface are sixteen to eighteen axial ribs which extend down to the base of the body whorl although less distinct than on the center; they do not extend up to the collar but reappear as nodes on the rim of the collar. These are crossed by eleven or twelve smaller revolving ribs which are closely set on the lower part of whorl, but more widely spaced on convex portion where their intersection with axial ribs produces nodes. In over 100 specimens examined there are always four nodes to each axial rib on the convex part of whorl and 16 to 18 rows. Spire moderately low; suture distinct; canal short; slightly bent with two plications; inner lip heavily calloused, extending up to central part of convex portion of shell; outer lip thin; aperture broad.

Dimensions.—Altitude 32.5 mm.; diameter 22 mm.; elevation of spire 6 mm.; angle of spire 70°.

Occurrence.—Loc. No. 57 (University of Washington Palaeontological Collection) up branch of Wilson Creek, Sec. 36, T. 10 N., R. 6 W., Wahkiakum County.

Horizon.—Wahkiakum formation, Lower Miocene.

GENUS FUSUS LAMARCK.

FUSUS MONTESANOENSIS n. sp.

Plate VI, Figure 58.

Description.—Shell large, solid, with six rounded whorls; suture distinct and slightly appressed; apex acute; body whorl plump with four faint but distinct angles, the upper one being most pronounced; spirally sculptured by five major revolving ribs between each of which are four or five less distinct ribs; about 13 or 14 faint varices cross the whorls and appear especially on the angles of the whorls of the spire as nodes. They are not very prominent on the body whorl. In addition there

are numerous barely noticeable fine incremental lines; aperture moderately wide; canal long and nearly straight. Some of these specimens retain their original coloring.

Dimensions.—Altitude of specimen 60 mm.; maximum diameter 37 mm.; apical angle 35°.

Occurrence.—At Station No. 68 (University of Washington Palaeontological Collection) in the basal conglomerates of Montesano formation on Sylvia Creek about six miles north of Montesano, Chehalis County.

Horizon.—Montesano formation, Upper Miocene.

GENUS PLEUROTOMA LAMARCK.

PLEUROTOMA CHEHALISENSIS n. sp.

Plate XI, Figure 90.

Description.—Shell moderately large, slender, fusiform; apex acute, whorls nine, nodose, spirally sculptured and distinctly angulated; surface of whorls above angle flat to concave; lower surfaces flat in whorls of spire but decidedly concave on body whorl; an obscure angle occurs on lower part of body whorl; on the angle of the body whorl there are 18 not very well developed nodes which disappear immediately above and below the angle, with interspaces of about twice their width. On the whorls of the spire they keep becoming more pronounced and extend as ridges from the angles down to the suture and range in number from 10 to 14. These nodes do not, however, extend on the surface from the angle up to the suture. Surface of all the whorls is ornamented by numerous clearly defined regularly alternating major and minor raised revolving lines; posterior sinus well developed; surface of all whorls crossed by numerous bowing incremental lines which conform to the posterior sinus; inner lip smooth, extreme end of canal broken, but apparently nearly straight; aperture elliptical; angle of spire 40°.

Dimensions.—Altitude from end of spire to broken end of canal 44 mm.; restored length 52 mm.; latitude 20 mm.; length of spire 25 mm.

Occurrence.—At Station No. 31 (University of Washington Palaeontological Collection) in sandy shale one-half mile west of Lincoln Creek Station, Thurston County, in railway cut.

Horizon.—Lincoln formation, Oligocene.

PLEUROTOMA WASHINGTONIANA n. sp.

Plate III, Figure 31.

Description.—Shell small, slender, apex acute; whorls 7 to 8, distinctly angulated and nodose; lower surface of whorl slightly convex; upper surface concave; surface of body whorl sculptured by ten distinct revolving ribs all of which are confined to the angulated ridge and the surface below it. Three obscure ribs appear above in some specimens; of those occurring below three are stronger than the remainder; angular ridge of body whorl set with 16 nodes which also occur on all whorls of spire; surface of shell strongly sculptured with incremental lines which are undulating and correspond to the sharply incised posterior sinus; apex of sinus above angular ridge. Canal moderately long and nearly straight with one faint plication; inner lip smooth; outer lip thin; aperture narrow, and elongate.

Dimensions.—Altitude to broken end of canal 28 mm.; diameter 10 mm.; elevation of spire 16 mm.; angle of spire 20°.

Occurrence.—At Loc. No. 90 (University of Washington Palaeontological Collection) in bluff one-half mile west of Porter, Chehalis County, along railway track.

Horizon.—Blakeley formation, Lower Miocene.

GENUS DRILLIA GRAY.

DRILLIA CHEHALISENSIS n. sp.

Plate VI, Figures 65, 66.

Description.—Shell large, slender, fusiform; apex acute; whorls 9 or 10, angulated, very slightly concave above the angle, slightly convex below the angle on the body whorl, but approximately straight on the whorls of the spire; suture distinct, appressed. Ten well defined wave-like ridges cross each whorl at the angle forming nodes; above the angle these twist to the right and dwindle away half way to the suture; below the angle

they twist downwards to the left for a very short distance and disappear. Body whorl sculptured by 30 rounded, well defined, equally developed revolving lines; between each of these are one and sometimes two minor revolving lines. This ornamentation is also characteristic of the spire. Canal long and twisted outward; inner lip smooth and heavily incrusted with callous. Outer lip sharp; posterior sinus fairly well marked; aperture elongate and elliptical; surface ornamented by numerous lines of growth corresponding in curvature to the posterior sinus; angle of spire 25°.

Dimensions.—Altitude 80 mm. and 75 mm.; diameter 25 mm. and 22 mm.; length of spire 39 mm. and 37 mm.

Occurrence.—Very common and characteristic at Porter; Loc. No. 160 (University of Washington Palaeontological Collection) and Port Blakeley Loc. No. 13.

Horizon.—Blakeley formation, Lower Miocene.

SCAPHAPODA.

GENUS DENTALIUM LINNAEUS.

DENTALIUM PORTERENSIS n. sp.

Plate XIII, Figure 113.

Description.—Shell large, slightly curved; angle of divergence 9° to 14°; cross section circular; shell substance very thick in both young and old specimens; surface nearly smooth but showing about 35 very faint longitudinal lines; maximum diameter 9 mm.

Occurrence.—At Loc. No. 90—about one-half mile west of Porter on bluff on north side of Chehalis River, Chehalis County.

Horizon.—Blakeley formation, Lower Miocene.

BRACHIOPODA.

GENUS TEREBRATULA KLEIN.

TEREBRATULA OAKVILLEENSIS n. sp.

Plate XIII, Figure 107.

Description.—Shell medium sized, elongate; posterior valve thin, beak small and moderately incurved; greatest width about

two-fifths the length of the shell from posterior end; above this the margins of shell taper sharply and evenly to the beak; anterior end very evenly and broadly rounded; dorsal valve thin but slightly more convex than the ventral. There is no distinguishable fold on the dorsal, nor sinus on the ventral valve. Surface of both valves ornamented by numerous very fine concentric striae. There are no radiating ribs.

Occurrence.—From Station No. — (University of Washington Palaeontological Collection) about one mile west of Oakville on Northern Pacific track, in sandstone overlying basalt.

Horizon.—Blakeley formation, Lower Miocene.

ARTHROPODA.

CRUSTACEA.

Certain portions of the Blakeley formation are characterized by hard flinty semi-calcareous concretions which, when cracked open nearly always contain the fossil remains of crabs. Many of these are well preserved. They occur most abundantly in the shale bluffs at Porter, Chehalis County and in the northern part of Pacific County, north of the town of Menlo.

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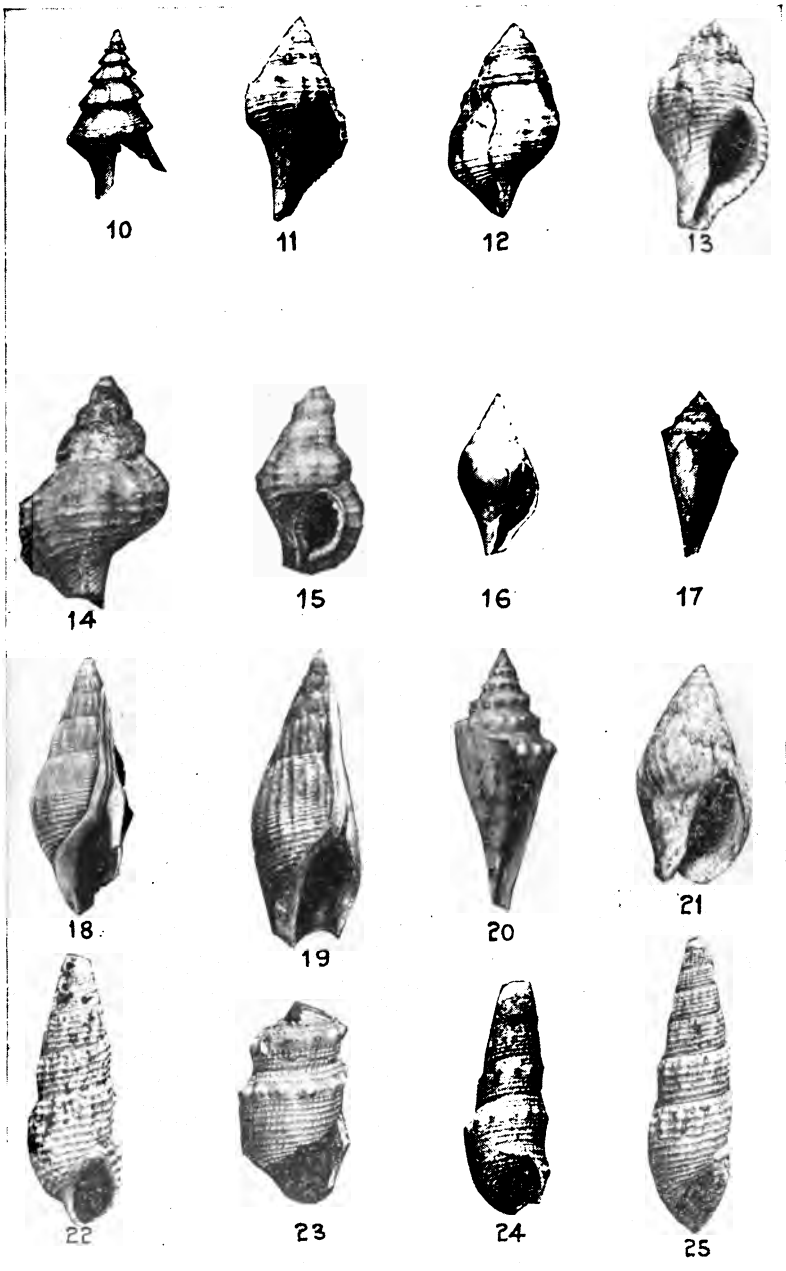
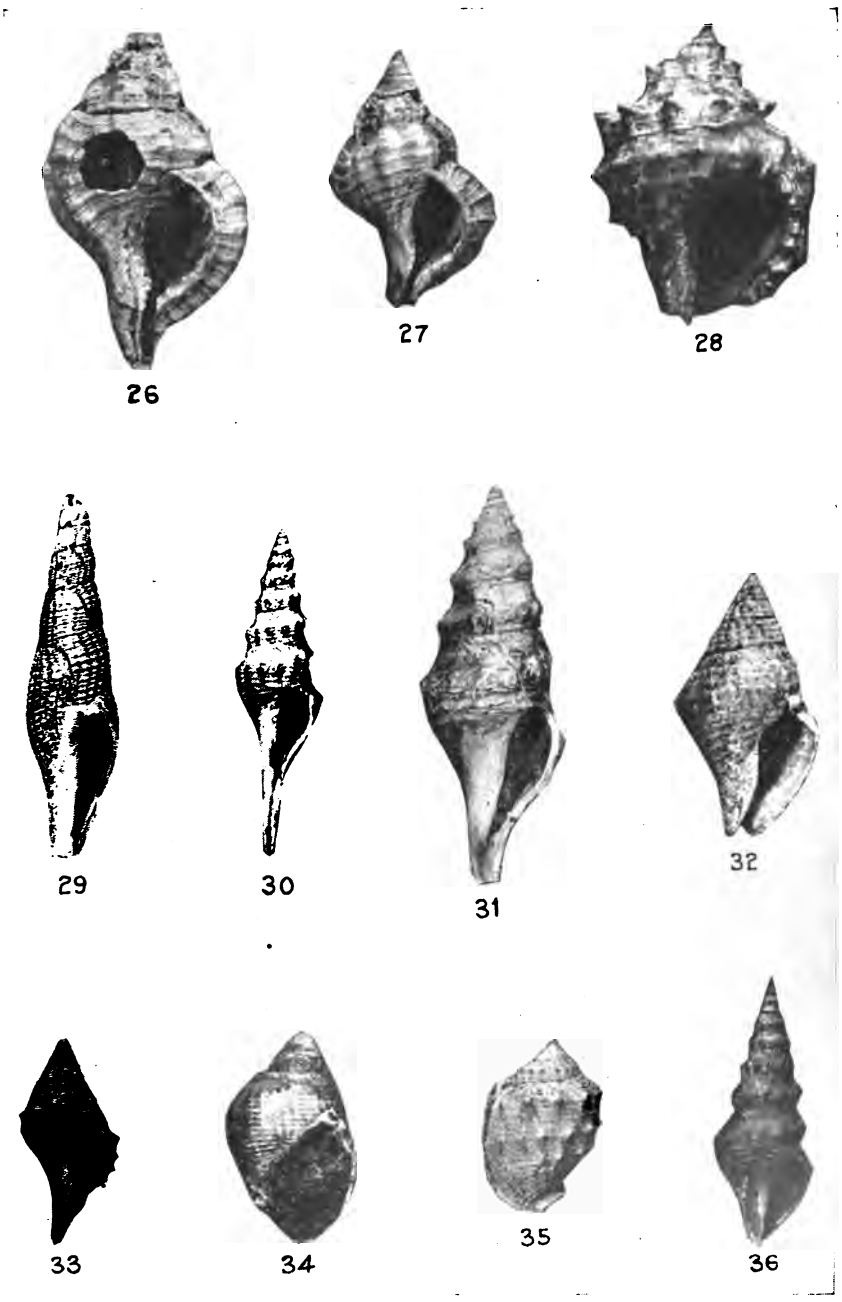
1. Hamifusus cowlitzensis.
2. Hemifusus sopenahensis.
3. Hemifusus sopenahensis.
4. Hemifusus cowlitzensis.
5. Fasciolaria washingtoniana.
6. Tritonium sopenahensis.
7. Murex cowlitzensis.
8. Murex sopenahensis.
9. Hemifusus lewisiana.

(All new species.)



10. Fusus washingtoniana.
11. Hemifusus washingtoniana.
12. Hemifusus washingtoniana.
13. Hemifusus.
14. Ranella washingtoniana.
15. Ranella cowlitzensis.
16. Mitra washingtoniana.
17. Conus horni Gabb.
18. Rimella canalifera Gabb, var. elongata n. var.
19. Rimella canalifera Gabb, var. elongata n. var.
20. Conus cowlitzensis.
21. Ancillaria bretzi.
22. Potamides lewisiana.
23. Potamides fettkei.
24. Potamides fettkei.
25. Potamides lewisiana.

(All new species.)



26. Ranella cowlitzensis.
27. Ranella cowlitzensis.
28. Cassidaria washingtoniana.
29. Fusus dickersoni.
30. Surcula cowlitzensis.
31. Pleurotoma washingtoniana.
32. Nassa eocenica. (Enlarged twice.)
33. Fusus lewisensis.
34. Nassa packardi. (Enlarged twice.)
35. Morio tuberculatus Gabb, var. tri-tuberculatus.
36. Surcula cowlitzensis.

(All new species.)

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37. Ostrea fettkei.
38. Brachysphingus charki.
39. Ostrea fettkei.
40. Crassatellites cowlitzensis.
41. Meretrix landesi.
42. Crassatellites washingtoniana.
43. Meretrix landesi.

(All new species.)

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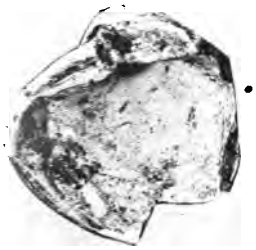

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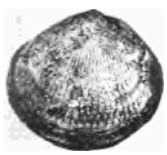

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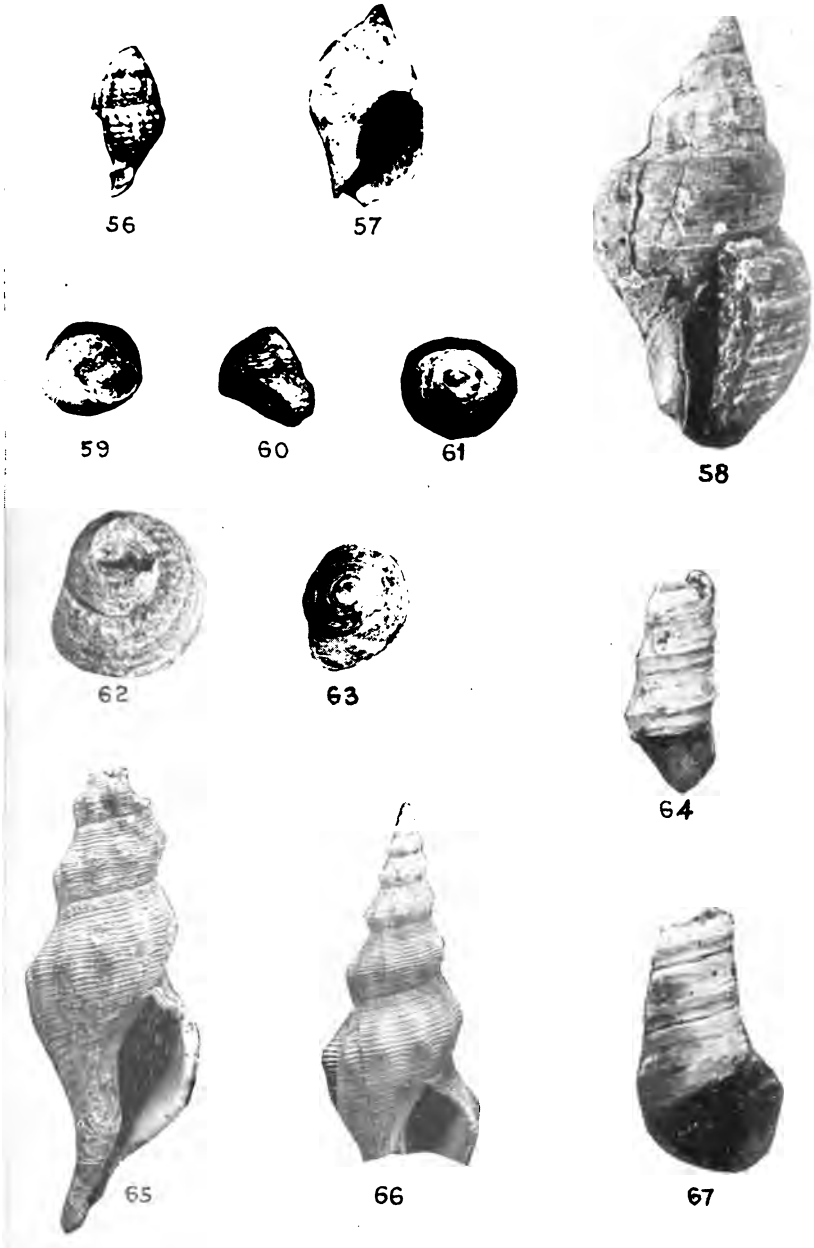
44. Rhynconella washingtoniana.
45. Rhynconella washingtoniana.
46. Pecten cowlitzensis.
47. Meretrix olequahensis.
48. Meretrix olequahensis.
49. Meretrix olequahensis.
50. Meretrix olequahensis.
51. Crassatellites washingtoniana.
52. Pectunculus eocenica. (Natural Size.)
53. Pectunculus eocenica. (Natural Size.)
54. Pectunculus eocenica, var. landesi n. var. (Natural Size.)
55. Cardium olequahensis. (Natural Size.)

(All new species.)



56. Nassa andersoni. (Enlarged twice.)
57. Brachysphingus clarkii.
58. Fusus montesanoensis.
59. Caliostoma delazinensis.
60. Caliostoma delazinensis.
61. Caliostoma delazinensis.
62. Chlorostoma arnoldi.
63. Caliostoma delazinensis.
64. Turritella blakeleyensis.
65. Drillia chehalisensis.
66. Drillia chehalisensis.
67. Turritella blakeleyensis.

(All new species.)

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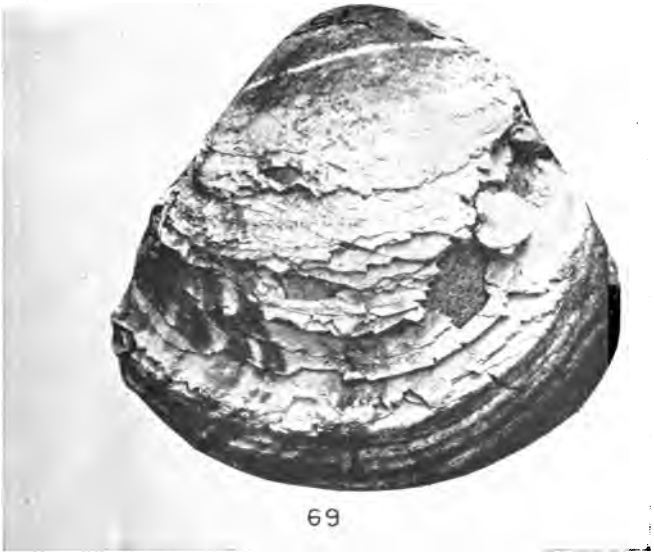

68. Pseudocardium gabbi Remond var. robustum.
69. Pseudocardium gabbi Remond var. altus.

(New varieties.)

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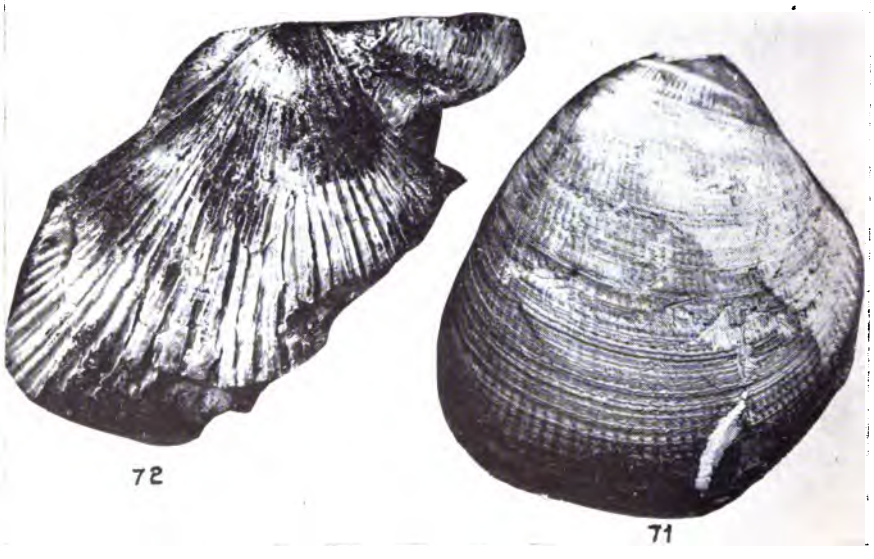

70. Pecten porterensis.
71. Chione chehalisensis.
72. Pecten porterensis.

(All new species.)

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73. Ficus clallamensis n. sp.
74. Tellina merriami n. sp.
75. Pseudocardium landesi n. sp.
76. Pseudocardium gabbi Remond var. undiliferum n. var.
77. Spisula albaria Conrad.

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78. Pseudocardium gabbi Remond var. elongatus n. var.
79. Chione cathcartensis n. sp.
80. Macoma montesanoensis n. sp.
81. Tellina merriami n. sp.
82. Tellina kincaidi n. sp.

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83. Turritella porterensis.
84. Turritella porterensis.
85. Turritella blakeleyensis.
86. Surcula cowlitzensis.
87. Turris wynootcheensis.
88. Turris wynootcheensis.
89. Turris wynootcheensis.
90. Pleurotoma chehalisensis.
91. Cuma biplicata var. quadranodosum.
92. Cuma biplicata var. quadranodosum.
93. Cuma biplicata var. quadranodosum.
94. Turris wynootcheensis.

(All new species.)

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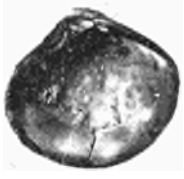

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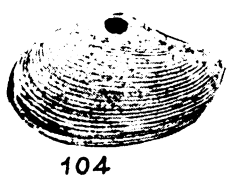

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95. Chione montesanoensis.
96. Marcia oregonensis.
97. Chione montesanoensis.
98. Semele montesanoensis.
99. Semele montesanoensis.
100. Semele sylviaensis.
101. Venericardia chehalisensis.
102. Venericardia chehalisensis.
103. Chione montesanoensis.
104. Leda chehalisensis.
105. Leda chehalisensis.

(All new species.)

106

107

108

109

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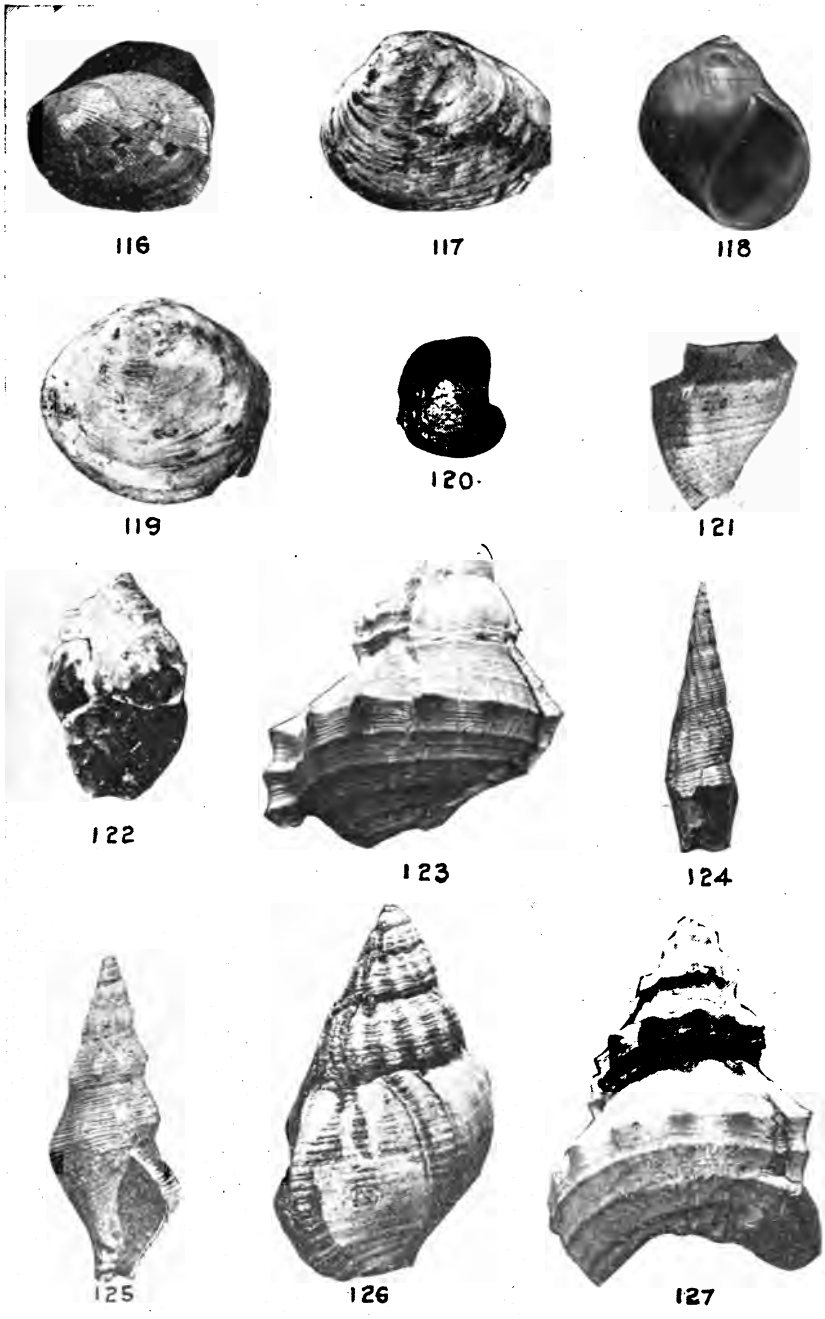
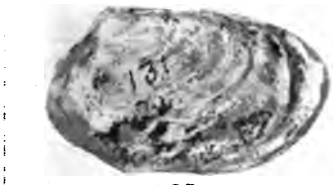
106. Yoldia sammamishensis.
107. Terebratula oakvilleensis.
108. Tellina n. sp.
109. Macoma snohomishensis.
(Enlarged twice.)
110. Mytilus snohomishensis.
111. Mytilus sammamishensis.
112. Sharks tooth.
113. Dentallium porterensis.
114. Cryptomya washingtoniana.
115. Pecten alockamanensis.

(All new species.)



116. Crenella porterensis n. sp.
117. Corbicula cowlitzensis n. sp.
118. Lunatia hornii Gabb.
119. Corbicula eufaulaensis n. sp.
120. Cardium sp.
121. Turris wynootcheensis n. sp.
22. Cuma biplicata Gabb var. quadranodosum n. var.
123. Tritonium n. sp.
124. Fusus dickersoni n. sp.
125. Drillia chehalisensis n. sp.
126. Gyrineum sylviaensis n. sp.
127. Tritonium n. sp.



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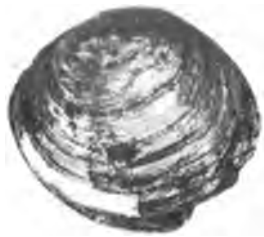

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128. Macoma wynootcheensis.
129. Macoma wynootcheensis.
130. Macoma wynootcheensis.
131. Corbicula eufaulaensis.
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134. Pectunculus tejonensis. (Natural size.)
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137. Venericardia chehalisensis.

(All new species.)

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Volume 2.—Annual Report for 1902. Part 1, The Building and Ornamental Stones of Washington, by S. Shedd; part 2, The Coal Deposits of Washington, by Henry Landes and C. A. Ruddy. Postage 20 cents. Address, State Librarian, Olympia, Washington.

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WASHINGTON GEOLOGICAL SURVEY

HENRY LANDES, State Geologist

BULLETIN No. 16

Geology and Ore Deposits of the Covada Mining District

By CHARLES E. WEAVER

OLYMPIA, WASH.:
FRANK M. LAMBORN, PUBLIC PRINTER.
1918

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LETTER OF TRANSMITTAL.

Governor Ernest Lister, Chairman, and Members of the Board of Geological Survey:

GENTLEMEN: I have the honor to submit herewith a report entitled "Geology and Ore Deposits of the Covada Mining District," by Charles E. Weaver, with the recommendation that it be printed as Bulletin No. 16 of the Survey Reports.

This report, which involves but little more than a reconnaissance survey, has been prepared at the urgent request of the mining men of the Covada district. For some time there has been a contention between the miners and the Indian claimants in regard to the character of the land in this district—whether or not it contains mineral deposits of probable or assured economic value. In this bulletin Dr. Weaver has set forth the bare facts regarding the general geology of the district, the character of the ore deposits, and a brief description of the individual mining properties. It is regretted that a lack of money has prevented the preparation of a detailed report upon this interesting district, but the hope is expressed that the report as it stands may prove to be of some value to the mining men of Covada and to others who are interested in metal mining in Washington.

Very respectfully,

HENRY LANDES,

State Geologist.

University Station, Seattle, June 2, 1913.

CONTENTS.

ILLUSTRATIONS.

INTRODUCTION.

FIELD WORK AND ACKNOWLEDGMENTS.

This report was undertaken primarily for the purpose of determining the mineral or non-mineral character of certain mining claims in the Covada Mining District, lying within the south half of the Colville Indian Reservation, in Ferry County. In many cases allotments of agricultural or grazing lands which were being made to the Indians included parts or all of a large number of mining claims. These allotments are now being contested by the mining men of the Covada district.

It was attempted in the investigation of this region to make a geological examination of each individual claim that was in contest. Such examination included a study of the rock formations, the character and extent of the ore bodies, a representative average assay from each claim and a record of the amount and character of development work completed. Note was also made of the general character of the area of each claim for agricultural or grazing purposes. Because of insufficient time, many claims which were not in contest were not visited. On many of the latter considerable development work has been done. It is believed that sufficient data have been obtained to construct a geologic map of the district and to determine the relation of the ore bodies to the geological formations.

No topographic map of this region has ever been made. A small generalized map has been constructed by Mr. Buell Robinson of Covada for the Covada Commercial Club, and upon this the roads, streams, hills, and section lines are represented. In a general way modifications of this have been used as a base map for representing the areal geology in this report. A map showing the position of the various mining claims has been constructed. Their positions can only be regarded as approximate, as detailed surveys have been made in only a very few cases. It is possible that some claims whose names or positions could not be determined have been omitted.

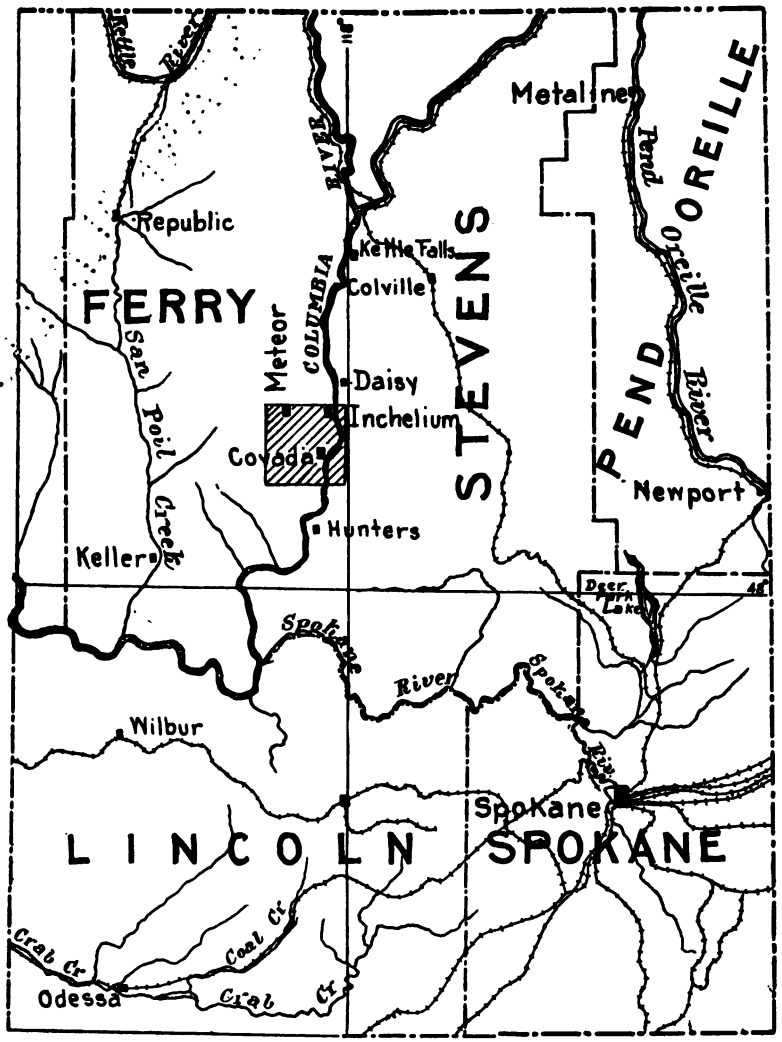

FIG. 1. General Reference Map.

The geological field work was carried on in the summer of 1912, between July 20th and August 15th. Portions of the succeeding winter months have been devoted to working up the data collected during the summer and in preparing this report. The chemical analyses included within the report were made by Mr. F. M. Ashton of the Department of Chemistry at the University of Washington, and the assays were made by Prof. C. R. Corey of the School of Mines at the State University.

The writer wishes to express his thanks to all who have assisted in this work, and especially to the members of the Commercial Club of Covada. At all times means were provided for transportation to different parts of the district, and persons familiar with the positions of claims and mine workings were detailed to accompany the writer.

LOCATION AND AREA OF THE DISTRICT.

The Covada Mining District is located a little south of the extreme east-central portion of Ferry County, in the northeastern corner of the State. It is situated adjacent to and just west of the Columbia River and forty-five miles south of the International Boundary, at about latitude 48° 15′ north and longitude 118° west. The district includes those mining claims situated west of Columbia River, south of Steinger Creek and north of Nez Perce Creek. It embraces the lower two-thirds of Township 32 North, Range 36 East, the greater part of the eastern third of Township 32 North, Range 37 East, and the north third of Township 31 North, Range 36 East. The total area involved is approximately forty square miles.

In the northwestern corner of the district, on Steinger Creek, in Section 17, Township 32 North, Range 36 East, is located the old mining town of Meteor. At present it consists of several cabins, only a very few of which are occupied. Covada is situated in the Northeast Quarter of Section 2, Township 31 North, Range 36 East, about one and one-half miles west of Columbia River. It consists of a few houses, a store, and post-office. The majority of the people are scattered about the district. There are no railroads within the district, but the topo-

graphic features are such that most points may be easily reached by wagon road. One wagon road extends southward from Covada to Hunter's Ferry on the Columbia, and thence down the river. The route most usually traveled in reaching Covada is from Spokane northward seventy-three miles on the Great Northern Railway to Addy. From Addy there is a tri-weekly stage connection with Gifford, a small settlement on the east side of the Columbia River, nineteen miles distant. A ferry across the river connects this town with Inchelium, which in turn is connected with Covada by seven miles of wagon road. The trip may be made by rail from Spokane to Meyers Falls, by stage from there to Daisy, by ferry across the river and thence by road to Covada. Meteor may be reached by wagon road either from Gifford or Daisy. In either case the journey may be made in one day. In an air line Covada is thirty-five miles southeast from the Republic Mining District, but there is no direct connection by wagon road. One small steamer plies between the settlements along this section of the Columbia. From Covada there is a bi-weekly mail service by way of Addy, and a long distance telephone connection by way of Davenport.

LITERATURE.

There is practically no literature bearing directly upon the geology of this district and up to the present time no areal geological work has been done. The region is a part of what has been called the Okanogan Highlands, and many of its geological features are very closely related to those in other parts of this province which in places have been studied. Inasmuch as reference will be made to these quite often in this report, a short abstract with occasional quotations will be given of those papers where the geological conditions are most similar to those at Covada.

Hodges, L. K., Mining in the Pacific Northwest. PP. 105-116, on the Colville Reservation. Published by the Seattle Post-Intelligencer, Seattle, 1897.

This paper describes in a brief manner the general geography of the Colville Reservation. The north half had been thrown

open to mineral entry in 1896. A short description is given of the several mining properties as they existed in 1897. No reference is made to any mining activity in the Covada region. Those properties existing to the southeast of Covada in Stevens County and those to the northeast in the vicinity of Meyers Falls and Colville are described.

Landes, Henry, Thyng, Wm. S., and Lyon, D. A. Metalliferous Resources of Washington, except Iron; Ferry County, pp. 50-52, Annual Report, Vol. I., Washington State Geological Survey, 1901, Olympia, Washington.

At the time when this report was published very little prospecting had been done in the Covada district. No direct reference is made to the (Covada-Meteor) camp. A few general statements are made concerning the geology and ore deposits of the county as a whole. "As to the geological features of the county, it may be noted in a general way that granite, gneiss, schist, and crystalline limestone are the prevailing formations, with some intrusive and extrusive rocks of a late age. A broad belt of granite, flanked by gneiss, schist and crystalline limestone, lies immediately to the westward of the Columbia and Kettle rivers, and extends from the southern to the northern limits of the county."

Mathews, G. A., Covada Camp. Northwest Mining Journal, Vol. 3, pp. 72-74, No. 5, August, 1909. Seattle, Washington.

The location and area of the camp are defined. The principal rock formations are said to be "granite and diorite, traversed by a series of eruptive dikes. The mineral bearing veins are of the true fissure type, * * *. The dikes are of frequent occurrence, of variable size and character, and are most generally of porphyry. The strike of the leads is * * * northeast and southwest. The dip is 20 to 40 degrees and to the west." The greater part of this article is confined to a description of the various properties in this district.

Staff Correspondence, Operations in the Covada District, Washington. The Mining World, Vol. 33, pp. 367-368, No. 9, August 27, 1910, Chicago, Ill.

This paper, after giving the location of the district, is confined almost entirely to a description of the development of the

different properties and remarks concerning the character of the ores. A small map of the district is inserted. It is a copy from that constructed by Mr. Buell Robinson of Covada.

Bancroft. Howland. Lead and Zinc Deposits in the Metaline Mining District, Northeastern Washington. Bulletin 470, United States Geological Survey, pp. 188-200, 1911, Washington, D. C.

This district is located fifty miles northeast of Covada. Many of the geological features of the two districts are similar. Certain data gathered about Metaline may throw some light on the situation at Covada. The formations consist of "a thick series of more or less dynamo-metamorphosed sedimentary rocks, composed essentially of shale and dolomite." These strata are believed to be of Paleozoic age and several thousand feet in thickness. No igneous rocks were observed. The ores are thought to have been derived from "solutions which may have accompanied the granitic intrusions seen throughout a large part of northeastern Washington, tongues of which probably extend into the Metaline district."

Umpleby, Joseph B. Geology and Ore Deposits of the Republic Mining District. Bulletin No. 1, Washington Geological Survey, pp. 1-65, Olympia, Wash.

The Republic District is roughly thirty-five miles northwest of Covada, but topographically and geologically the two districts are very closely related. In the Republic report a description is given of the topography, physiography, general geology, economic geology and principal mines. "The greater part of the Colville Indian Reservation is regarded as a part of that physiographic unit which is known as the Interior Plateau, and which is bounded on the west by the Coast Range and on the east by the Gold Range and which extends north to the Mackenzie River and, if relations here suggested be correct, it extends south to the Columbia River. South and west of this great unit is an erosion surface recognized as post-Miocene in age." The geologic formations consist of "the metamorphic equivalents of a great series of shales, sandstones, limestones and lava flows, which are of Paleozoic age." These are re-

garded as belonging to Carboniferous time. During the Mesozoic there were granodiorite intrusions. Following these there was "a great period of erosion which may be divided into two parts; a first of base leveling and a second of elevation and erosion. Into these valleys formations of Oligocene age were deposited. They consist of dacite flows, andesite breccias, lake beds, and andesite flows. These are cut by intrusive latite porphyries with which the ore deposits are thought to be genetically related. During the Pleistocene the entire area was glaciated.

CHAPTER I.

PHYSIOGRAPHY.

TOPOGRAPHY.

GENERAL STATEMENT.

The topography of the area involved in the Covada district is characteristic of that of northeastern Washington. It is a part of that physiographic province known as the Okanogan Highlands, which is regarded as the southern extension of the interior plateau of British Columbia. This great plateau is bounded on the west by the Cascade Range of Washington and British Columbia, and on the east by the Gold Range of the Rockies. It is terminated on the south by the Miocene basaltic plateau of eastern Washington. The east-west course of Columbia River in Lincoln County is the dividing line between the two plateaus. The plateau north of the river ranges from one to three thousand feet higher than that to the south and is traversed by several large river valleys extending from north to south, which open out into Columbia River. Columbia River itself, after first crossing the International Boundary, trends south across this plateau to its junction with Spokane River, and then turns west.

The region involved in the Covada district lies a little over half way south from the International Boundary to Spokane River, and within the valley of Columbia River. Columbia River has carved its canyon from the summit of the plateau to the present river level, leaving broad terraces on either side at various elevations.

DRAINAGE.

The entire drainage of the Covada district finds its way directly to Columbia River. There are no large streams traversing it. The northern part of the area is drained by Steinger Creek, which, just north of the area mapped, joins Hall Creek

and within three miles empties into the Columbia. The southwestern portion of the area is drained by Nez Perce Creek, which reaches the Columbia a short distance south of the limits of the map. The central part of the area is traversed by several small creeks which are dry in the summer, but which in winter drain through Covada Creek to the Columbia. A number of little lakes are scattered through the region which receive a small amount of the surface water.

Steinger and Nez Perce creeks are very small but carry some water throughout the entire year. They occupy flat and moderately wide valleys with low grades except near the Columbia, where they descend rapidly. Much of the water apparently seeps below the level of the stream beds. No official records of the volume of water passing through these creeks have been made. Numerous springs occur throughout the district.

FORMS OF THE SURFACE.

The lowest elevations within the district are along Columbia River and range from twelve to thirteen hundred feet above the sea. The entire central portion of the area is a mountain mass trending northwesterly from the Columbia, where it ultimately merges into the main divide between San Poil and Columbia rivers. Within the limits of the area mapped, a mountain spur forms the divide between Steinger and Hall creeks on the north and Nez Perce Creek on the south. This mountainous area is divided by a deep gulch trending northwest and southeast, known as Stray Dog Canyon. The hills to the north and east are comparatively low and rounded; those to the south and west are higher and more rugged. This valley ranges in width from 200 to 600 feet, and near the town of Covada widens out towards the river. The slopes toward Stray Dog Canyon are steep and rugged and in many places precipitous, with talus slopes below. The slopes on the west towards Nez Perce Creek are comparatively gentle and rolling. In Section 30, Township 32 North, Range 37 East, lies Rattlesnake Mountain, a bold, rocky mass with a steep slope to the west and north, but a more gentle one to the south and east.

GLACIATION.

There is direct evidence within this district that even the highest knobs on the mountain tops have been glaciated. Glacial grooves and striations in the hard country rock are very well defined. Observations were taken at numerous points and without exception the striations were always trending in the same direction—nearly due north and south. Very little drift is strewn over the surface, but occasional erratics of rock foreign to this district are found. Along the western border of the Columbia, for a distance of nearly a mile back from the river, the bed rock formations are covered with non-consolidated gravels, clays and sands. Occasionally they are partly stratified. They may be in part of glacial origin. Several distinct terraces have been cut into them and these in turn have been dissected by small gullies rapidly descending to the Columbia.

CLIMATE.

The climate at Covada is representative of that in Ferry and Stevens counties. The winter temperatures are somewhat lower than at Spokane and perhaps a little higher than at Republic. The annual rainfall is about the same as at Republic and Spokane. Snow begins falling in November and generally disappears in late April. During the winter Columbia River often freezes over so as to allow teams to cross. No official climatic records have been kept at Covada or Meteor. The nearest points at which such records have been kept are Republic, Spokane, Colville, and Wilbur. The following tables are taken from the United States Weather Bureau records:*

*Summary of the Climatological Data for the United States by Sections; Section 20, Eastern Washington, by Willis L. Moore, U. S. Department of Agriculture, Weather Bureau.

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Location	Elevation Feet	Annual Precipitation	January	February	March	April	May	June	July	August	September	October	November	December
Republic.....	2,628	17.42	1.73	1.33	1.36	1.40	2.20	1.78	1.21	0.59	1.04	1.07	1.93	1.79
Spokane	1,943	17.89	2.36	1.89	1.40	1.19	1.51	1.50	0.66	0.54	0.98	1.35	2.17	2.39
Colville.....	1,635	17.66	2.23	1.73	1.36	0.96	1.91	1.51	1.19	0.76	0.79	1.18	2.18	1.86
Wilbur.....	2,208	14.33	1.86	1.64	0.88	0.86	1.50	1.07	0.58	0.50	0.69	1.25	1.76	2.14

FROST DATA.

STATIONS	Length of Record Years.	Average date first killing frost in autumn.	Average date last killing frost in spring.	Earliest date killing frost in autumn.	Latest date killing frost in spring.
Colville.....	9	September 7	June 5	August 21	July 26
Republic.....	8	September 3	June 15	August 26	July 29
Spokane.....	28	October 14	March 26	September 7	June 8
Wilbur.....	9	September 6	June 23	August 17	July 30

The highest temperature ever recorded at Republic was 102°; at Colville, 103°; and at Spokane, 104°. The lowest temperature recorded was at Republic, —32°; at Colville, —29°; and at Spokane, —30°.

Since the elevation of Covada approaches that of Colville, the yearly temperature and rainfall will compare closely with observations at the latter place, the nearest point at which records have been kept.

VEGETATION.

Almost the entire district about Covada is covered with timber consisting chiefly of the following varieties:

Yellow pine (*Pinus ponderosa*)
Tamarack (*Larix occidentalis*)
Red fir (*Pseudotsuga mucronata*)
Sticky laurel (*Ceanothis velutinus*)
Huckleberry (*Vaccinium macrophyllum*)
Thimbleberry (*Rubus parviflorus*)

Along the benches leading down directly to Columbia River the timber is very scattered and in many places absent. Over the greater part of the region, in common with the Okanogan Highlands, the forests are open, with very little underbrush except along the slopes of the canyons. It is possible to drive a team

almost anywhere among the trees. The only timber which has been cut is that used in the construction of local buildings.

RELATION OF THE PRESENT TOPOGRAPHY TO THE GENERAL GEOLOGY.

The explanation of the present topography of this district must be sought in a study of the geological conditions which occur throughout the Okanogan Highlands and of which the Covada region is a part. Geologic investigations of this broad area have been made, both in British Columbia and Washington, and as a result a fairly definite conception has been formed of the geological processes involved in developing the present topography. The Okanogan Highlands are regarded as a separate physiographic province from either the Cascades or the basaltic plateau of southeastern Washington. Their physiographic history is thought to be entirely separate. Evidence near Republic and in other parts of Okanogan and Ferry counties suggests that the entire area north of Columbia River during Eocene time was reduced to a peneplain. This is thought to have been coincident with a similar peneplanation in the interior plateau of British Columbia.

During the Miocene, elevation of the peneplaned surface seems to have occurred. Accompanying and following this, stream cutting developed broad and deep valleys which acted as basins for the accumulation of vast quantities of later Tertiary lavas, tuffs, stream gravels and lake deposits. Diastrophic movements undoubtedly were taking place during this time of which we have no definite record. During the Pleistocene the entire region seems to have been covered with a part of the Cordilleran glacial ice sheet. After the retreat of the ice, the drainage readjusted itself and the streams continued their downward cutting, ultimately developing the topography as it exists today.

Within the region involved in this report there are practically no data which can thrown any light on the early Tertiary physiography. Observations made from some of the higher ridges suggest a uniformity of elevations along the distant mountain

divides. Near the Columbia, on either side, definite terraces may be seen which have been carved from old stream or glacial deposits. There is a suggestion that the difference in elevation on the east and west sides of Stray Dog Canyon is due to an original terrace carved into bed rock. The small valleys and canyons seem to be of comparatively recent development and the result of drainage adjustment as Columbia River was gradually deepening its valley. The characteristic rounding of many of the hill tops and slopes is probably due to the action of the ice sheet.

CHAPTER II.

GENERAL GEOLOGY.

INTRODUCTION.

The general geology of the Covada district has many characteristics in common with those at Republic and Metaline. The interpretation of certain data gathered here must be in part sought for from facts already learned in neighboring regions where studies have been made. Insomuch as no areal geologic mapping has been carried on in the broad intervening areas it is impossible to make exact correlations. Many of the formations well represented at Republic are totally absent at Covada and many best developed at Covada are very poorly represented at Republic. The same holds true for Metaline.

The oldest and most extensively developed formations at Covada are some more or less metamorphosed sediments, consisting of quartzites, schists, slates, and crystalline limestones, with metamorphosed interbedded lavas. No fossiliferous evidence has been obtained to determine their age. Similar rocks have been described at Republic* and Metaline†, and although no fossils were collected they were regarded as probably Carboniferous. The strata at Covada are provisionally assigned to the Carboniferous also. After their deposition they underwent deformation and were invaded by a great batholith of granodiorite which resulted in their metamorphism. Later both the metamorphics and granodiorites were cut by aplite dikes which were probably differentiated products from the granodiorite itself. Both the quartzites and granodiorites are also cut by dikes of andesite and pyroxenite porphyry. There is no evidence as to

*Geology and Ore Deposits of the Republic Mining District, Bulletin No. 1, part I, Washington Geological Survey, 1910, Olympia, Wash.

†Lead and Zinc Deposits in the Metaline District, Northeastern Washington, Bulletin No. 47, p. 192, U. S. Geological Survey, 1911, Washington, D. C.

the exact time of the intrusion of the latter. It is known that surface flows of lava similar in composition occur to the south in the plateau of eastern Washington, as well as to the west and north in the San Poil Valley and at Republic. These are known to be of Miocene age and the basic intrusives at Covada are assigned to that period. Unconsolidated gravels and sands, resting unconformably upon the older rocks, occur along the slopes of Columbia River and glacial erratics are scattered over the mountain tops.

COVADA FORMATION.

AREAL DISTRIBUTION.

Nearly one-half of the areal geology in the Covada district is composed of slates, schists, quartzites, and dolomitic limestones. Throughout the Okanogan Highlands and northward into British Columbia formations of a very similar character are extensively found. No areal mapping has as yet been undertaken in the south half of Ferry County and consequently the exact limits of the Covada formation are unknown. On the eastern side of the Columbia River, along the road to Addy, outcrops of quartzite occur in various places. Although the latter region has not been areally mapped it seems in large part to be composed of metamorphic material. Along both the east and west slopes of the river these old rocks are covered over with Pleistocene gravels and alluvium.

Within the Covada district proper the Covada formation occupies a very prominent place, covering about twenty square miles. It forms one irregular shaped mass, roughly concentric around a central core of Meteor granodiorite. In the north central part of the district some small areas are separated from the main body by Pleistocene alluvium and gravel. The smallest of these lies in the northern part of Sections 13 and 14, Township 32 North, Range 36 East, just north of Steinger Creek. The second area is situated just south of Steinger Creek in Sections 14, 15, 22, 23, in Township 32 North, Range 36 East. The third and largest area enters the northeast corner of the district just west of Columbia River as a belt nearly two

miles wide. In passing southward it narrows to a width of about one mile southeast of Covada postoffice.

South of Covada the formation occupies the entire area between Columbia River and Nez Perce Creek. About three miles west of Covada it turns northward, and in Section 29, Township 32 North, Range 36 East, it narrows down to less than one thousand feet. It widens again, passes northwesterly, crosses Steinger Creek just west of Meteor townsite and passes out through the northwestern corner of the district.

GENERAL DESCRIPTION.

The rocks entering into the Covada formation consist of slaty schists, siliceous slates, quartzites, argillaceous quartzites, and dolomitic limestones. This entire series originally was composed of sandstones, shales, grits, tuffs and limestones which have since been more or less metamorphosed. The quartzites range from very fine to very coarse grain in character. Where they have been most intensely metamorphosed they are hard and dense with a glassy luster. Where metamorphism has been less pronounced the small component grains are found to be angular and very little water-worn. In some places the quartzites are dark gray, in other places a sugary white. Near the contact with the granodiorite batholith the quartzites have been intensely fractured and crushed and the seams have been filled with quartz and very acidic portions of the granodiorite magma. In some places the quartzite is completely filled with a network of small quartz stringers less than one-sixteenth of an inch in thickness. The slates vary considerably in character. In many places they are simply slightly hardened shales, while in other places they pass into sericitic schists. Commonly the slates show that they were originally composed of alternating layers of sandy shale and argillaceous sandstones, often in narrow bands only a fraction of an inch in thickness. This characteristic is well developed on Reister Mountain, south of Covada. In the hills just west of the Columbia River, and especially just north of Rattlesnake Mountain, dolomitic limestones are very

common. They are of a grayish blue color and are interbedded with the quartzites and slates. Near the contact with the intrusive granodiorites they take on a crystalline appearance. The prevailing strike of the strata is due north and south, and the dip nearly vertical. In the vicinity of the granodiorite contact the rocks have been badly displaced and contorted.

No evidence of fossil remains, either plant or animal, have been found. A fossil fish about two feet in length is said to have been collected from the dolomitic limestone near Rattlesnake Mountain, but it was not seen by the writer.

The Covada formation as a whole seems closely related in its general characteristics to that described in the Metaline district, in the Republic district, and with the Cache Creek beds of British Columbia.* It resembles the Peshastin formation of the central Cascades of Washington.† Provisionally its age may best be assigned to the Carboniferous or possibly early Mesozoic.

METEOR GRANODIORITE.

AREAL DISTRIBUTION.

The central portion of the Covada district is areally characterized by a large mass of granodiorite. In addition a narrow belt extends north and south along the western margin of the map, separated from the central mass by a belt of Covada quartzite. Altogether the total area of granodiorite represented upon the map is about eleven square miles. Outside of the Covada district it outcrops extensively, although its exact boundaries have never been mapped. The high hills north of Covada and south of Steinger Creek are composed of this rock and Stray Dog Canyon has been carved in it. Just east of Covada postoffice a small, irregular shaped tongue extends southward to within one mile of Columbia River, where it is overlaid with the older metamorphic rocks. Immediately east of Meteor it extends to Steinger Creek and, although not ex-

*Ann. Rept. Geol. Surv. Canada, New Series, Vol. 7, 1894, pp. 37B-49B.

†Mount Stuart Folio, No. 106, p. 3, 1906. U. S. Geological Survey.

amined by the writer, from there it is said to extend northwesterly far beyond the limits of the map. In several places within the areas studied as the Covada formation, small outcrops of granodiorite may be seen penetrating the quartzite. These are small, with ill-defined boundaries and have not been represented upon the map.

GENERAL DESCRIPTION.

There is much variation in the appearance of the granodiorite in different parts of the district. In many cases the rock is of a distinctly plutonic character and from that passes into a porphyritic condition. The plutonic type prevails. Rather frequently the granodiorite phase passes to the granitic phase. Orthoclase and quartz gradually become more abundant. Biotite predominates as the ferromagnesian constituent in all types, although hornblende is often very abundant. Generally the rock assumes a grayish color, but sometimes possesses a bluish tint. Occasionally it is a pinkish white when it assumes the characteristics of an aplite. Several distinct phases occur in this district and a separate description of each will be given.

Specimen No. 34.

This phase is found in various parts of the granodiorite area, but is best developed in the Syndicate tunnel in Stray Dog Canyon, where this specimen was secured. It is a medium grained rock composed chiefly of plagioclase, biotite, orthoclase, quartz and hornblende. Plagioclase constitutes over sixty per cent of the rock. Much of it has a reddish gray tinge. The biotite occurs in very small flakes evenly scattered through the mass. Under the microscope a few very small accessory crystals of titanite and apatite were observed. Plagioclase occurs in well developed crystals ranging from 0.3 mm. to 0.2 mm. in size. They are nearly all twinned on the albite law, but occasionally in combination with Carlsbad and pericline laws. A few of the crystals show zonary banding, although this is not especially common. Examinations of a large number of crystals show them to have

General view of topographic features in the vicinity of the lower tunnel at Advance Mine.

a composition of Ab. 60 An. 40, which falls in the Andesine class. A few of the crystals are basic oligoclase.

Biotite is abundant and of light brown color, showing intense pleochroism. It occurs in irregular leaves, although sometimes with fairly definite boundaries. Orthoclase is not abundant. It occurs in small crystals generally exhibiting Carlsbad twinning, and often shows rough crystallographic outlines. Quartz constitutes only five or six per cent of the rock. It appears in irregular grains along with the orthoclase, and was one of the last minerals to crystallize. Occasionally a few large crystals may be seen in the hand specimens. The accessory constituents are apatite, titanite and magnetite, which are present only in small amounts.

Specimen No. 33.

This type approaches the granite family more closely. Quartz is abundant and orthoclase occurs in slightly greater amounts than plagioclase. The rock as seen in hand specimens is of a light gray color and of medium grain. Crystals of quartz, orthoclase, plagioclase and biotite may be distinctly seen. This type of rock in the field grades over into that described under Specimen No. 34. Specimen No. 33 was collected from the Black Thorn claim in Stray Dog Canyon. Under the microscope orthoclase is seen to be a very prominent constituent. It occurs in large crystals commonly showing Carlsbad twinning and sometimes perthitic structure. As a rule it is fairly free from alteration, although sometimes fine white micaceous aggregates may be observed along the cleavage lines. The soda lime feldspars occur in subordinate amounts and are very acidic. They fall into the Oligoclase series and have an average composition of Ab. 75 An. 25. They commonly show albite striation and occasionally zonary structure. Decomposition is more pronounced than in the orthoclase, giving rise to mica and chlorite. Quartz is much commoner than in the type represented by Specimen No. 34. It occurs in small irregular grains as well as in large allotriomorphic crystals. It is sometimes full of fluid inclusions, but more often is clear and fresh. In a

few cases it is intergrown with orthoclase. Biotite is the most abundant dark mineral. It has a yellowish to greenish brown color with very strong pleochroism. Many of the crystals are decomposed to green chlorite and brown iron oxide. A very few slender prisms of apatite are seen and occasionally one of zircon. This type grades into the true granodiorite.

APLITE.

In a number of localities dikes of aplite may be seen outcropping on the surface in both the granodiorite and old metamorphic formations. As a rule they are much decomposed and crumble easily. The most prominent exposure occurs southwest of Rattlesnake Mountain, in sections 25 and 36, Township 32 North, Range 36 East. It is nearly one mile in length and trends north and south. The ore deposits on the Longstreet and Fidalgo claims are associated with this dike. Other smaller outcrops occur north of Covada postoffice on the St. Patrick and Royal Ann claims.

Specimen No. 28.

This specimen is representative of aplite within this district. It is a medium to coarse grained rock composed almost exclusively of quartz and orthoclase. The latter is always more or less altered, giving the rock as a whole a yellowish to greenish appearance. Quartz and orthoclase are present in about equal amounts and occur in fairly good sized crystals which are sometimes intergrown. Under the microscope the orthoclase occurs in hypidiomorphic crystals partly intergrown with quartz. Only a few show Carlsbad twinning. Perthitic structure is common. Nearly every crystal of orthoclase is clouded with patches of alteration products consisting chiefly of fine muscovite, some chlorite, and all more or less stained with iron oxide. Because of the decomposed condition they stand in marked contrast to the quartz. The quartz occurs in large irregularly rounded crystals, the largest of which are about one-eighth of an inch in diameter. Nearly all of the crystals are filled with inclusions which are commonly arranged in bands and their exact deter-

mination could not be made. One or two very small primary crystals of muscovite were seen in hand specimens, but they are very uncommon.

GRANODIORITE PORPHYRY.

Small dikes of granodiorite outcrop in the quartzite in several localities. They represent little apophyses of the magma which have extended up into the metamorphic formation. A specimen representative of this dike was collected in the northeast quarter of Section 36, Township 32 North, Range 36 East, on the Rosaria claim. The dike here is about 800 feet long and trends north and south.

Specimen No. 63.

This specimen, which is typical of the entire exposure, is medium grained and composed of plagioclase feldspar, quartz, orthoclase, biotite and augite. With these are imbedded larger crystals of plagioclase. The rock as a whole is badly decomposed. Some specimens have a very close resemblance to a quartzite. The plagioclase is of the andesine variety. It nearly always shows albite striations and in some cases is completely altered to calcite and muscovite. The quartz is present in small amounts in irregular grains and crystals. It is fresh and unaltered but nearly always free of inclusions. Augite is abundant and partly altered to iron oxide. Biotite occurs as a primary mineral composing about three per cent of the rock.

ANDESITE DIKES.

Dikes of igneous rock of andesitic composition occur, cutting through the granodiorite and Covada metamorphic formations in several places in the district. Two small dikes outcrop in Section 35 and in Section 22, Township 32 North, Range 36 East. Others occur in the northwest quarter of sections 3 and 10, Township 31 North, Range 36 East. On the surface the dike rock is much weathered, but it generally stands out prominently from the surrounding rocks. In the workings of the Advance Mine a dike of similar rock has cut the vein and to a certain extent taken its course along the vein. Here it is com-

pletely decomposed. One of the freshest specimens and one most characteristic of this rock was taken from the south end of Reister Mountain, about two miles southwest of Covada postoffice. The dike is about twenty feet wide and strikes north and south. It is here confined within the quartzites and slates of the Covada formation.

Specimen No. 59.

This is a dark gray rock, fine grained, with crystals of hornblende and biotite set in a finer grained groundmass. The feldspars are badly decomposed and iron stained. Under the microscope the rock is found to be composed of hornblende, biotite, plagioclase, augite and very small amounts of orthoclase and hypersthene.

Among the phenocrysts are hornblende, augite and biotite, but no plagioclase crystals. The groundmass is composed of small microlites of plagioclase with a slight tendency to flow arrangement. Scattered among these microlites are small grains of augite. The augite crystals are colorless as a rule. Hornblende occurs in long prisms and exhibits strong pleochroism. Biotite occurs in large ragged flakes with strong absorption. The plagioclase microlites yielded maximum symmetrical extinction angles of 38°, giving it a composition of basic labradorite.

PYROXENITE.

Only one dike of this material occurs within the district. This dike is about 4,000 feet in length and over 100 feet in width and trends roughly N. 40° E. It is situated about three miles west of Covada postoffice in Section 33, Township 32 North, Range 36 East. The rock of this dike is best represented by Specimen No. 38, which is here described.

Specimen No. 38.

This is a hard, dense, dark gray rock composed entirely of pyroxene. On the surface it is much weathered and iron stained. When unweathered and studied under the microscope it is found to be a compact mass of enstatite crystals with a very small

amount of augite. No plagioclase was observed. In some specimens the enstatite is partly altered to serpentine.

QUATERNARY.

The most important geological work accomplished during the Quaternary period consisted of glaciation, stream cutting, and stream deposition. Scattered over the surface of most parts of this district are glacial erratics, more or less rounded and grooved, composed of rocks entirely foreign to this region. Ample evidence is afforded by well defined glacial grooves and striations that the great ice-sheet from the north passed over this portion of Washington. Along the valley of Columbia River are deposits of stratified and non-stratified unconsolidated sediments, partly the work of ice and partly the work of running water. These deposits rest unconformably upon the older Covada formations. Several terraces have been developed and into these later Quaternary gullies and small canyons have been cut. By far the larger part of the original deposits have been removed by erosion so that only remnants now remain clinging to the bed-rock valley slopes.

STRUCTURE.

The more important structural features in this district have been largely determined by the intrusions of granodiorite masses, accompanied by uplifts. The entire region is underlaid with portions of the granodiorite batholith. Around the margins of the district the metamorphic formations rest upon the granodiorite concentrically. The prevailing strike of the metamorphic formation is north and south and not concentric with the central mass of the batholith. The strata appear to have been tilted into a nearly vertical position, and the granodiorite injected parallel to the bedding planes. Very little folding could be observed, although more detailed investigations may show close folding and repetition of the strata. No very extensive faults have as yet been discovered, although minor dislocations are common. In the Meteor mine a fault has dislocated

the vein, but its extent can not as yet be determined. No prevailing direction of faulting has been observed.

GEOLOGICAL HISTORY.

From such evidence as can be obtained from the study of the quartzites, schists, slates and limestones of the Covada formation, this particular region was probably a part of a broad marine basin during late Paleozoic and Mesozoic times. Apparently there were variations from time to time in the depths of water, allowing the coarse grained sandstones and conglomerates to accumulate near shore, and the finer sediments such as shales to form in deeper waters. The limestones give evidence of considerable depth. At intervals during the accumulation of this series, volcanic activity seems to have been more or less prevalent. Thin narrow deposits of metamorphosed volcanic tuffs and lava flows are interbedded with the sediments. The total thickness of this series approximates ten thousand feet as a minimum and is possibly much greater. Whether sedimentation continued throughout the Triassic and Jurassic is at present uncertain because of lack of fossil evidence. At some time, probably near the close of the Jurassic, this entire region was invaded from below by a great mass of plutonic magmas of intermediate chemical composition. These magmas were in the nature of a batholith and in the process of intrusion underwent extensive differentiation, giving rise to all variations, ranging from a granodiorite to a granite. These molten magmas in places seem to have engulfed huge blocks of quartzite from the roof of the batholith. Many apophyses from the magma penetrated up into the Covada formation in the form of dikes. Near the contact the metamorphic rocks are intensely sheared and the small fractures are filled with the more siliceous portions of the granodiorite. In many places the quartzite possesses a chert-like appearance, cut by thousands of small intersecting veinlets of silica and granite. This condition becomes less pronounced at some distance from the contact.

After the upper portion of the batholith had consolidated, extensive fracturing seems to have occurred as a direct result of

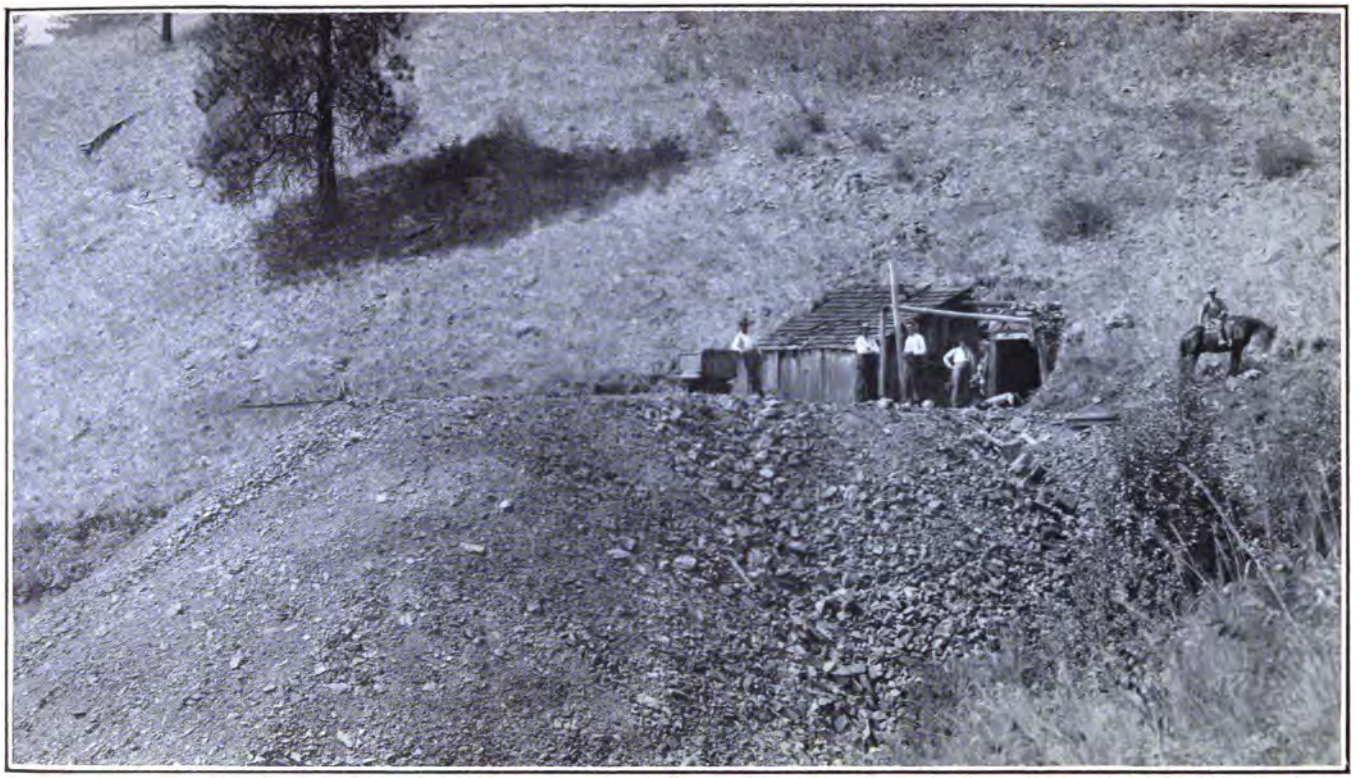
shrinkage from consolidation. The more siliceous portion of the still molten magma along with the salts of the minerals occurring here seems to have been differentiated and drawn off into the fracture zones as magmatic emanations. As these gradually approached the surface they conformed to the physical and chemical laws of solution and upon a decrease of temperature and pressure, formed precipitates. These are now thought to be the veins found outcropping in this district. After intrusive activity had become quiescent the region underwent vigorous erosion. It had probably been uplifted above sea-level into a high mountain mass either just before, contemporaneous with, or soon after the granodiorite intrusion; we have no evidence here to determine the exact date of uplift. Concerning the geologic history during the Cretaceous, Eocene, Miocene and Pliocene periods we have no definite information.

Some distance away to the northwest, at Republic, the three latter periods were characterized by outpourings of volcanic lavas alternating with accumulations of sediments in fresh water lakes. To the south, in the great Columbia plateau, volcanic activity was the dominant feature of the Tertiary. Within the Covada district proper no surface deposits of Tertiary age are present. They may have formerly existed, but if so every vestige of them has been entirely removed by erosion. There are several small narrow dikes of andesite and pyroxenite lavas cutting both the granodiorite and the Covada metamorphic formations. They are probably of Teritiary age and may have been feeders to some pre-existing lava flows which once covered parts of this district.

Evidence obtained from other districts to the north suggest that the Covada region, along with that of the Okanogan Highlands, during the Eocene was reduced to a peneplain and this is considered a part of the great interior Eocene plateau extending northward into British Columbia. After the close of the Pliocene the first definite information which we have of the geological history is largely that of erosion and glacial action. Columbia River has been continuously cutting down its channel

to its present position through this broad peneplained area. The several benches occurring at various elevations above the present bed of the river indicate former positions of the stream.

The entire region about Covada has been glaciated. Glacial deposits may be found along the slopes of the river canyons, and erratics occur even on the tops of the highest mountains. Well defined glacial grooving and scouring are strongly developed in the rock ledges along the mountain slopes. Such marks invariably have a north-south direction, indicating that a portion of the great Cordilleran ice-sheet once moved over and completely covered this district. After the retreat of the ice the drainage lines immediately began to readjust themselves to the changed topography. The present topographic features are the product of these various physiographic developments.



General view of mine workings at the Orion Mine.

CHAPTER III.

ECONOMIC GEOLOGY.

HISTORY OF MINING.

Mining activity within the Covada district is of comparatively recent date. The district is located within the south half of the Colville Indian Reservation, which was thrown open for mineral entry by act of Congress, July 4th, 1898. Ore deposits were known to exist here a number of years before the reservation was opened for mining development. The Indians are reported to have displayed numerous specimens of high grade float for twelve or fifteen years before the opening.

The Covada region was officially included within the Enterprise mining district, situated in the most southeastern section of the Reservation. It is described as follows:*

"Beginning at the mouth of Wilmot Creek, thence up the Columbia River to the north line of the south half of the Colville Reservation; thence following the north line of the said south half, west to the summit of the range or divide between the San Poil and Columbia rivers; thence in a southerly direction to the headwaters of Wilmot Creek; thence following Wilmot Creek to the mouth or place of beginning." The most extensive work has been done in what are commonly called the Covada, Meteor and Columbia camps. The Columbia camp includes most of the properties east of the road from Covada to Gifford.

The first location made in the Covada camp was the Apex group, now known as the Big Chief, by Edgar Balling in 1898. The first location made in the Meteor camp was the Vernie, by H. Garrett and W. A. Pea, in 1899. The Meteor, which is the

*Typewritten document submitted by Mr. H. G. Parmeter of Covada.

best developed property in the Meteor Camp, was located in the same or the following year by Edgar Balling. The claims which now comprise the Meteor townsite and for which patent was issued in 1904 or 1905, were located in 1900 by Archie Wilson. The postoffice at Meteor was established in 1901, and that at Covada on October 10, 1905.

TREATMENT AND SHIPMENT OF ORES.

The greater part of the ores in this district requires metallurgical treatment, and they cannot be considered as free milling. The following data concerning shipments and treatment have been furnished by Mr. H. G. Parmeter of Covada:

In 1902 a car load of ore was shipped from what was then known as the Stray Dog property, now known as the Hercules Group, at a cost of $24.00 per ton and which gave net returns of $80.00 per ton. In 1904 five tons were shipped which netted $80.00 per ton, and in 1907 a car load which returned $72.00 per ton. In 1907 a mixed car was shipped from the Meteor mine to the Tacoma smelter at a cost of $24.00 per ton, for freight and treatment. This netted $96.00 per ton for first class and $52.00 per ton for second class ore. In 1905 1,935 pounds were shipped from the Silver Crown which gave net returns of $168.00 for the shipment. From the Silver Leaf 2,800 pounds were shipped to Trail, B. C., at a cost of $25.00 per ton, which netted $77.00 per ton to the owners. Two shipments of five tons each in 1912 were sent to the Granby smelter at a cost of $27.00 per ton and yielded net returns of $92.00 per ton.

In 1909 thirty-eight sacks of ore were shipped from the Longstreet property to Northport, which netted $77.00 for the lot. In the same year a car load was also shipped from this property which was very satisfactory, but the exact figures are not obtainable. Numerous other shipments have been made but opportunities for gathering full details regarding them have not been available.

The average cost per ton for freight and treatment is approximately as follows:

Wagon freight to railroad.....	$10.00 to $12.00
Railroad freight, about.....	6.00
Treatment	6.00
Total.....	$24.00

DISTRIBUTION OF THE ORE BODIES.

The larger part of the ore bodies within the Covada district lie in a belt about five miles long from east to west and four miles wide from north to south. This belt begins about one mile west of Columbia River and south of Rattlesnake Mountain, and extends westerly through the south half of Township 32 North, Range 36 East, to the slopes leading down to Nez Perce Valley. It includes Advance Mountain, Meteor Mountain and Rattlesnake Mountain. It is terminated on the north by the valley of Steinger Creek and on the south by the south lines of sections 1, 2, 3, 4 and 5, Township 31 North, Range 36 East. There are ore bodies outside this area, but they are more scattered and less persistent. The vein occurring on the Guin property on the north of Steinger Creek may be regarded as an exception to this general statement.

CHARACTER OF THE ORE BODIES.

The majority of the ore bodies occur in well defined fissure veins, chiefly within the granodiorite mass or in the Covada metamorphic formation not far from the contact. In a number of instances, however, the veins consist of impregnated country rock along zones of fracturing. The vein materials consist of quartz and occasionally calcite, carrying silver and lead with smaller amounts of gold, copper and antimony. The commercial values are chiefly in silver. In the upper or oxidized zone the veins generally consist of rusty, iron-stained, decomposed quartz and altered country rock occasionally containing small grains or crystals of galena. No very deep workings exist, but in those localities where the veins have been opened

nearly at right angles to the former, although no definite regularity may be said to exist. In and near the aplite dikes antimony occurs in unusually large amounts, and in places it is impregnated through the aplite, or at least through certain zones within it, as may be seen on the Rosario and Longstreet claims.

MINERALOGY.

The ores in this district are chiefly composed of galena, carrying some silver, together with pyrite, sphalerite, chalcopyrite and very small amounts of sylvanite and ruby silver. The gangue mineral is nearly always quartz. In the surface outcrops it is commonly much oxidized, giving it a reddish brown, decomposed, honeycombed appearance. In the lower workings of the mines, the quartz is generally fresh and often shows ribbon structure. The ores are generally impregnated through the quartz gangue in the form of small, irregular shaped grains or bunches. In a number of places calcite forms the gangue material, but has been introduced subsequent to the quartz and as a rule does not carry values.

Quartz.

Quartz is the most abundant mineral in the veins of this district and ordinarily occurs in a milky white form with more or less of a banded structure. Grains of galena are abundantly distributed through the quartz. In the oxidized zone near the surface it commonly assumes a rusty, reddish brown color and contains secondary material introduced by infiltration from the surrounding wall rock.

Calcite.

Calcite in places occurs as a gangue mineral, but it is not at all abundant. It is often banded and assumes a yellowish or reddish tinge due to impurities introduced from without. Although no deep development work has been done upon the calcite veins yet they seem to be found chiefly near the surface. This mineral has undoubtedly been introduced at a later time than the silica solutions.

Limonite.

This mineral appears in the oxidized zone of the quartz veins as a reddish-yellow, rusty-colored stain on the quartz or filling small cavities formerly occupied by pyrite. It owes its origin to the alteration of the iron sulphides.

Pyrite.

Pyrite is fairly common in the veins throughout the entire district. It occurs in both crystalline and massive form. Sometimes it is intergrown with the galena and chalcopyrite or sphalerite. It is often somewhat disseminated through the country rock adjacent to the veins. Near the surface it is nearly always more or less oxidized.

Chalcopyrite.

Occasionally small and irregular shaped grains of chalcopyrite are found scattered through the quartz veins. It is not common and as an ore mineral in this district is of no economic importance.

Galena.

Next to quartz, galena is the most abundant mineral in the veins of this district. It is scattered in large or small grains throughout the quartz gangue. It generally occurs in crystalline form or aggregates of crystals. Massive bunches are very often over one foot in diameter. Assays show that it generally carries more or less silver. It is not commonly altered, but in a few places it is found to be coated with oxide or carbonate of lead.

Stibnite.

Next to galena, stibnite is of the most importance among the metallic minerals. Small amounts of it are found associated with nearly all of the veins in the district. In the hills just south and west of Rattlesnake Mountain it is abundantly associated with aplite dikes. The mineralized zones in the aplite range from one to six feet in width. Often these zones are more than half composed of stibnite and bluish quartz.

Sphalerite.

Sphalerite is common, and in a number of places abundant, but not present in sufficient quantities to be of economic importance. It occurs scattered through the quartz gangue in small masses and crystals generally mixed with galena or pyrite.

Molybdenite.

This mineral occasionally is found in those veins outcropping in the granodiorite. It is not at all common and usually appears in very small flakes.

Silver.

Native silver sometimes occurs in wire-like forms, in small cavities in the quartz veins and generally is intimately associated with galena.

Sylvanite.

In a number of places in the Covada camp sylvanite occurs in small flakes about the size of a pin head, scattered through the quartz. It has a silver white color and occasionally appears in crystalline form.

Pyrargyrite.

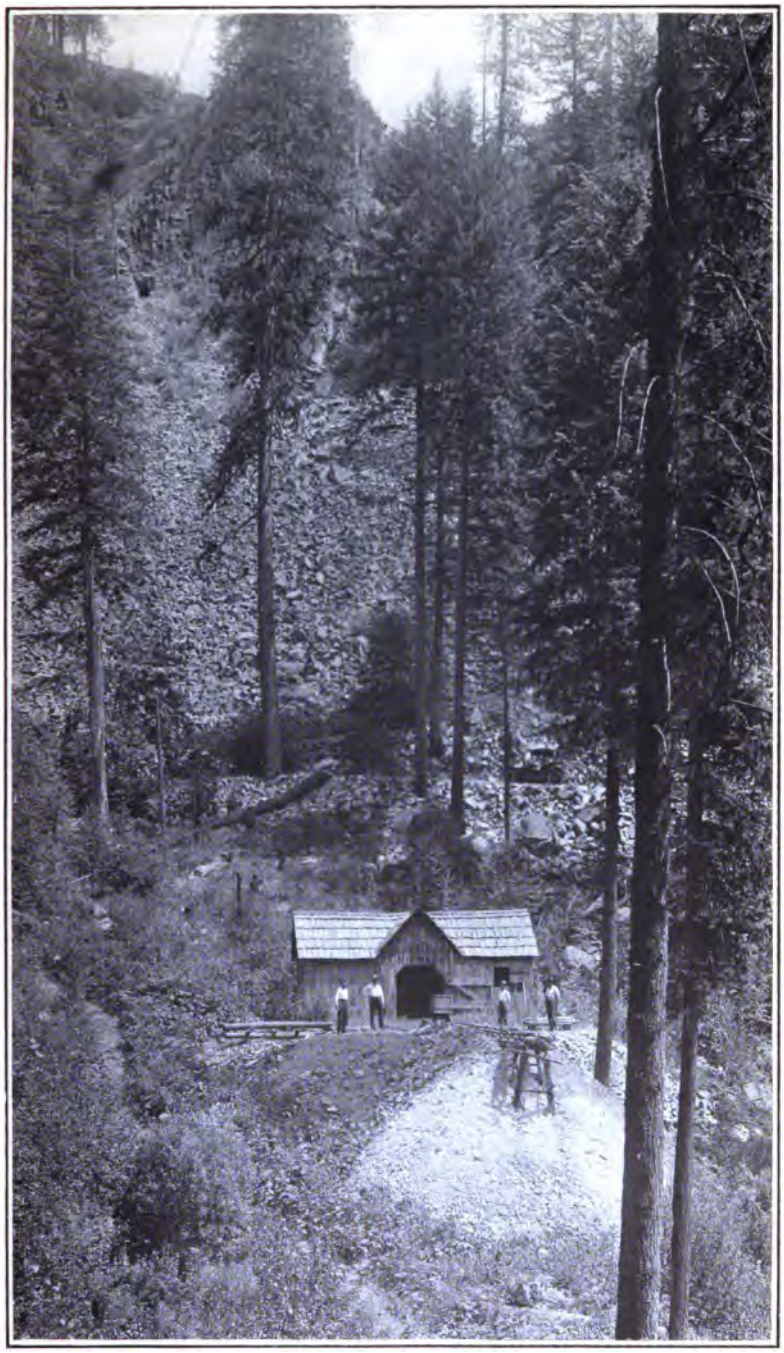
This silver mineral is very similar to sylvanite in its distribution through the quartz veins. The small crystals of it are, however, in many cases much larger than those of sylvanite.

Gold.

Gold is not of prime importance in the Covada district. In a few instances specks of native gold may be seen in the quartz. Average assays taken from the different veins in this district yield varying values in gold. It seems to occur in a finely divided state in some of the quartz veins.

GENESIS OF THE ORES.

The veins of the Covada district are entirely confined to the Meteor granodiorite and the Covada metamorphic formations. Included with the granodiorite are the aplite dikes occurring just west of Columbia River and Rattlesnake Mountain. The more



General view of talus slope, consisting of granodiorite blocks, on west side of Stray Dog Canyon; Black Thorn Mine in foreground.

basic dikes cutting through the granodiorite and metamorphic formations are much later than the mineralization and have no relation whatever to the genesis of the ores. In several places they cut through the quartz veins. The origin of the ores must be sought for in the granodiorite or quartzite. The Covada formation, consisting of quartzites, slates and limestones, is the oldest within this district and was laid down upon the sea-floor probably during the Paleozoic or early Mesozoic time. After the accumulation of these materials the region was elevated perhaps above sea-level, and either accompanying this elevation or at some time subsequent to it there was an invasion from below by portions of a great batholith. The magma within this batholith seems to have ranged from acidic to an intermediate chemical composition. Differentiation of this magma gave rise to subsidiary varieties ranging from the chemical composition of granite to that of the granodiorite. Within this district the latter seems to predominate.

Accompanying the intrusions there is thought to have been a fracturing of the rocks forming the roof of the magma. Later, upon the consolidation of the upper portion of the granodiorite batholith, there must have been attendant changes in volume. Such changes in volume would produce shrinkage not only in the upper portion of the consolidated magma itself, but also in the overlying capping of metamorphic rocks. This shrinkage would be accompanied by fracturing and fissuring. It is believed that the fracture zones, extending well down into the upper portion of the already consolidated magma, were the avenues through which magmatic waters found their way from the underlying batholith towards the surface. It is supposed that by the process of magmatic differentiation the more siliceous portions of the magma were drawn toward the surface into the fracture zones and that accompanying them were salts of gold, silver, lead, zinc, iron and antimony. The solutions containing these salts are assumed to have penetrated far up into the fracture zones and into the minor side fractures, and under reduced temperatures the mineral content to have been precipitated. In some cases

they seem to have acted upon the wall rocks and to have altered them to a certain extent, resulting in partial replacement and mineralization some little distance away from the true veins.

Dikes of aplite are found cutting the granodiorite and quartzite not far from the main contact. They appear to have been intruded at the time of, or just after, the principal invasion of the batholith. They are mineralized and it is believed that the metallic minerals associated with them have been differentiated from the granodiorite magma along with the differentiation of the aplite solutions.

The exact period of mineralization can not be definitely determined. It occurred later than the origin of the Covada metamorphic formation and either contemporaneous with or subsequent to the intrusion of the granodiorite batholith. It occurred prior to the intrusion of the andesitic dikes. Intrusions of granodiorite are known to have occurred extensively through the Cascades of Oregon and Washington, in California and British Columbia, at or near the close of the Jurassic period. It is quite possible that the intrusions in the Covada district were contemporaneous with those in the Cascades. If so, fissuring and mineralization occurred in the Jurassic. The andesite dikes which cut both the granodiorite and the Covada formation are probably of Eocene or Miocene age. Lavas very similar in character are extensively developed to the north and south of here, at Republic and on the basaltic plateau south of Columbia River. These are definitely known to belong to the Eocene and Miocene periods.

After the veins had been formed, this district in common with other parts of the Okanogan Highlands underwent extensive erosion, and in places the covering of quartzites and slates has been entirely removed, exposing the consolidated granodiorite itself as well as the mineralized fracture zones.

At Republic the ore bodies are thought to have been derived from solutions emanating from latite porphyries of Miocene age. In the Metaline district the ores are thought to have been derived from the granodiorite magmas, although they are not

exposed at the surface. The basic intrusions of Tertiary age in the Covada district can not possibly have been responsible for the introduction of the ore-bearing solutions and from such evidences as we now have the granodiorites are regarded as their source.

PLACER DEPOSITS.

Placer deposits in the Covada district are not of much importance. They are confined chiefly to the horizontally bedded sands and gravels along the slopes leading down to the Columbia River. These gravels and sands are found along the upper benches of the river as well as along the present flood plain. No very extensive development has ever been undertaken, but a number of claims have been located in sections 29 and 32, Township 32 North, Range 37 East. Water for sluicing has been obtained in small amounts from springs issuing from the eastern slopes of the hills, and then carried by flumes to the placer diggings. No data are available as to the values per cubic yard. The deposits are composed of materials ranging from the size of a pea to three or four feet in diameter. Interbedded with the gravels are sands and clays. They may be in part of glacial origin, but are largely derived by the work of streams.

CHAPTER IV.

DETAILED DESCRIPTION OF THE MINING PROPERTIES.

INTRODUCTION.

In the examination of the mining properties in this district, particular attention was given to those claims which were in conflict with Indian allotments. Several which were not in contest were visited and studied, but because of insufficient time some important claims were not seen. A careful examination of each claim in contest was made, and all discovery shafts, pits and open cuts noted. Samples were taken from each ore body in such a way as to represent an average for the entire vein. On some of the properties considerable development work has been done, while on others nothing has been accomplished beyond the yearly assessment work. Some of the claims have been abandoned and then relocated. At the present time there are approximately two hundred claims in the district; sixteen of these are patented. In describing each of these claims the more salient features will be presented, as follows: The geographical location; history of development; the underground workings and production; and the economic geology. The latter will include a description of the country rock, the form, distribution and character of the ledges, and their relation to the country rock.

THE ADVANCE MINING COMPANY.

The property of this company consists of nine claims located a little over one-half mile northwest of Covada postoffice, in Section 35, Township 32 North, Range 36 East. These claims are the Rising Sun, Cora, Nellie, White Quartz, Saturday, Cabin, Tamarack, Sunbeam, and Silver Spray. The larger part of the development work on this group has been done on the Cora and Nellie claims, which lie on what is locally known as Advance

Mountain. The outcroppings of the vein are fairly numerous and openings have been made upon it at many places. This vein varies in width from three to six feet and trends North 75° West, dipping into the hill at an angle of 70° to the northeast. It is reached in depth by two crosscut tunnels, one hun-

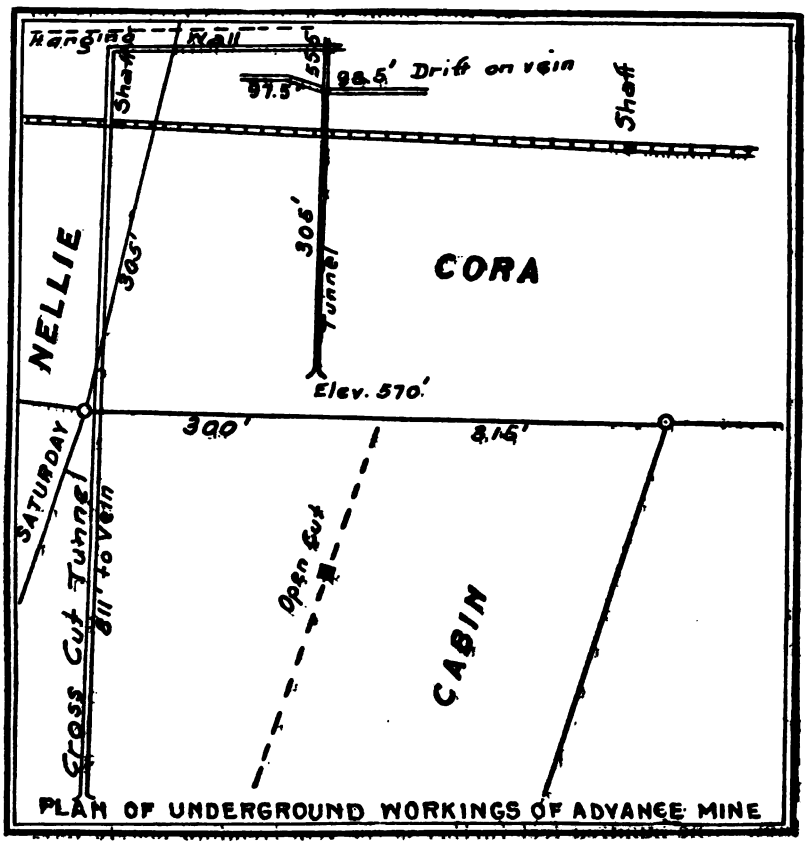


FIG. 2. Map showing mining claims and underground workings of the Advance Mine.

dred and seventy feet apart in elevation and connected by an upraise. The lower crosscut tunnel starts on the Cabin claim and has been driven in the direction North 15° East for a distance of 811 feet, where it intersects the vein at a depth of 307 feet. From this point a drift extends to the right upon the

vein. The vein is here trending North 75° West and dipping 55° to the Northeast. The country rock is granodiorite. About 75 feet from the west end of the drift the vein is locally deformed by an intersecting dike, and displaced by a slight fault. At this point the strike changes to North 55° West and the dip to 50° Northeast. Near this point a winze has been sunk on the vein to a depth of 60 feet. The average width of the vein seen in the winze is five feet. Above this an upraise has been driven for a distance of 170 feet to the upper crosscut tunnel.

The upper crosscut tunnel starts within the Cora claim near the south side line, and at a distance of 305 feet intersects the same vein 137 feet below the surface. It has been continued for 50 feet beyond the vein intersection and is entirely in quartzite. Drifts have been run from this level both to the right and left. To the left about 100 feet from the crosscut a winze has been sunk on the vein for 30 feet. Near here the vein is cut by a dike which follows its course in a sinuous fashion. It is quite altered and of the same character as the dike in the lower tunnel. The right-hand drift extends over 150 feet and connects with the lower drift by the upraise before mentioned. In addition to the underground workings several pits and cuts have been made upon the surface outcrops. Openings have been made upon the veins of the other claims, but the work for this group has been largely centered upon the Nellie and the Cora.

These claims lie very near the contact between the Covada metamorphic formation and the Meteor granodiorite. The lower crosscut tunnel is largely in the quartzite and slate. Seven hundred feet from the mouth is the granodiorite-quartzite contact. One hundred feet further is the vein trending nearly parallel to the contact and occurring in the granodiorite. In the upper tunnel the vein is entirely in the quartzite. The vein is of the fissure type and varies in width from six inches to six feet. Over a considerable distance it maintains the latter width. The gangue is quartz containing silver, gold, lead and zinc. A general assay of samples taken from the upper tunnel in the right-

hand drift gave the following returns: Gold, 0.04 oz. per ton; silver, 1.00 oz. per ton.

MAYFLOWER.

This claim is located in the northwest corner of Section 1, Township 31 North, Range 36 East. The northwest end extends into Section 36, Township 32 North, Range 36 East. It is situated only a few hundred feet southwest of Covada post-office and lies partly in the valley and partly on the hill slope. It is now owned by C. C. Rohlfs of Covada. The country rock is granodiorite, but the quartzite contact is close to the southeast end line. The development work on this claim is confined to assessment work. Outcropping in a few places is a vein of quartz which trends North 35° West and dips 45° Northeast. Several openings have been made upon this vein. At the foot of the hill just south of the store, a shaft has been sunk to a depth of 20 feet on the vein, which is here 18 inches wide. Further up the hill a second opening has been made on the same vein in granodiorite. Still further up the hill are two others, 20 feet apart and about six feet deep. The vein here is 18 inches in width and contains some galena. An assay of an average sample from this vein showed a trace of gold and 1.60 oz. silver to the ton.

LAKEVIEW FRACTION.

This claim is triangular in shape and lies immediately to the northeast of the Mayflower. It was located in 1904 and is now owned by C. C. Rohlfs of Covada. It lies in the granodiorite area, on a vein of quartz which trends North 40° West and dips 55° Northeast. The discovery shaft lies 600 feet from the north end line and is an open cut about eight feet deep. The vein is 12 inches in width with eight inches of granodiorite in its center. Several other smaller openings have been made upon the vein. The surface of the claim is rough and rocky. An average sample from this claim gave a trace of gold and 0.60 oz. of silver per ton.

PLYMOUTH ROCK.

This claim lies directly east of the Lakeview Fraction, and about 1,500 feet east of Covada postoffice. The country rock in the northern part of the claim is granodiorite and in the southern part quartzite. The discovery hole is 900 feet south of the north center end-line. The quartz ledge at this point is 34 inches wide and is well defined. It is composed of iron-stained, honeycombed quartz. The discovery tunnel, which is near the discovery hole, is 30 feet in length and has been driven in South 65° East as a crosscut to the vein. Within it the vein is well defined and trends North 50° West and dips 25° to the Northeast. About 12 feet east from discovery hole there is a shaft 32 feet deep. The vein here is well defined and is said to assay high in silver. One hundred and twenty-five feet from the center end-line there is an outcrop of rusty honeycombed quartz in a little pit. A sample from this claim assayed as follows: Lead, 6%; silver, 15 oz. per ton; gold, 0.01 oz. per ton.

PILGRIM.

This claim is the southeastern extension of the Plymouth Rock and joins it on its north end-line. It was located in September, 1904. The eastern and southern part of the claim lies in the quartzite and the western in granodiorite. The vein is an extension of the Playmouth Rock. It has about the same strike and dip, *i. e.*, 50° to the northeast. It lies very close to the contact of the granodiorite and quartzite. The development consists of the discovery pit and several small open cuts. An average sample from the claim gave the following returns in the assay: Gold, trace; silver, 0.60 oz. per ton.

BLUE BIRD.

This claim, located June 1, 1909, lies parallel to and west of the Pilgrim. On the north it joins the Mayflower. The country rock is granodiorite in the north part of the claim and quartzite in the southern part. The discovery hole is located 100 feet south of the north end-line. Another shaft 12 feet deep is situated a little further down the hill. It shows the slaty quartzite

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country rock, and the vein of greatly decomposed reddish quartz occurring in small stringers. Fifty feet east of this shaft there is a small tunnel running into the hill South 70° East. The vein material seems to be only silicified country rock which is largely quartzite and impure limestone. The formation strikes North 70° East and dips 25° Southeast. The assay of a sample from the discovery hole gives a trace of gold and 1.00 oz. of silver per ton.

QUANDARY.

This claim lies about 1,500 feet southeast of Covada postoffice. The discovery tunnel is an open cut 20 feet long, eight feet deep and three feet wide. The country rock is hard, banded quartzite. The tunnel runs due north and contains a thin layer of quartz.

KING SOLOMON.

The King Solomon claim is situated in the northwest quarter of Section 1, Township 32 North, Range 36 East, and about 1,000 feet south of Covada postoffice. The development work consists of several shafts, tunnels and open cuts. The discovery tunnel is situated at the north center end of the claim. The country rock there is granodiorite. There is a vein in it composed of quartz, with slight impregnations of galena. It has a strike of North 10° West and a dip of 30° Northeast. Very close to the discovery tunnel there is a shaft which was sunk to cut the discovery vein. It passes through granodiorite to a depth of 27 feet. About 100 feet from the side-line and 75 feet from the end-line a tunnel has been run in on a side vein for a distance of 25 feet in a direction North 70° East. By the side of this a shaft has been sunk on the vein to a depth of 15 feet. This is near the contact between the granodiorite and quartzite. At a point 150 feet from the end-line and 50 feet from the side-line a shaft has been sunk to a depth of 10 feet in quartzite. A small vein of quartz about four inches wide outcrops and strikes North 35° West, dipping 70° Northeast, but it is not the discovery vein. The granodiorite contact lies 10 feet to the east. Twenty feet to the north a small cut has been made on the same vein. Thirty feet farther north the same vein is at the contact.

Here a shaft has been sunk 10 feet deep. The vein is four inches wide with a strike of North 20° West and a dip of 70° to the Northeast. Near the center of the claim a crosscut has been run into the hill in a direction North 70° East for 50 feet to tap the vein. Another vein of very much decomposed, honeycombed, rusty colored quartz outcrops 500 feet from the north end-line and 60 feet from the east side-line. It is about one foot in width, strikes North 10° West and dips 70° Northeast. A small opening has been made upon it. The country rock here is quartzite. The assay of an average sample from the discovery vein shows a trace of gold and 7.80 oz. silver to the ton.

GREASY RUN.

This claim was located in 1907 and is now owned by A. B. Nickens of Covada. It is situated at Covada postoffice. The country rock is granodiorite overlain with alluvium in places. The extreme north end of the claim extends into the area of metamorphic rocks. The discovery, located 30 feet from the south center end, is a shaft sunk on the vein to a depth of 30 feet. This is a quartz vein containing galena and is about one foot wide, striking North 20° West, dipping 70° to the Northeast. About 15 feet west of the shaft there is an open cut about 15 feet long and 10 feet high which is extended as a crosscut to tap the vein in the shaft. On the south end-line, 50 feet from the east side-line, another shaft has been sunk in the granite to a depth of 30 feet. There is a small vein of quartz about four inches wide which is probably the same as before mentioned on the King Solomon. Near it there is a small outcrop of the same vein eight inches wide containing galena and pyrite. A sample from this claim gave the following assay: Gold, trace; silver, 2.20 oz. per ton.

SILVER PLUME.

This claim is situated in the northeast corner of Section 2, Township 31 North, Range 36 East, a few hundred feet west of Covada postoffice. It was located in 1907 and is now owned by G. W. Sizemore of Covada. At the discovery there is a two-foot quartz ledge striking North 65° East. The quartz is iron

stained and honeycombed, with crystals and small masses of galena scattered through it. Near it a crosscut tunnel has been driven due south for a distance of 165 feet to the intersection of the vein. At this point the vein strikes North 65° East and dips 55° Northwest. The vein varies considerably from the average width of two feet. The country rock is quartzite. The mouth of the tunnel is situated 200 feet north of the discovery shaft. At a point 500 feet northeast of the southwest end-line is a tunnel extending into the granite in a direction South 55° West for a distance of 60 feet on a vein of quartz about one foot or more in width. It is dipping 55° to the southeast. The vein material consists of white quartz more or less honeycombed and iron-stained, containing a considerable amount of galena.

WHITE TAIL.

This claim, located in April, 1911, is in the southwest quarter of Section 36, Township 32 North, Range 36 East, about one-half mile northeast of Covada postoffice. The discovery is located 100 feet north of the south end-line. A shaft has been sunk to a depth of 10 feet on the vein, which is about 14 inches wide and consists of iron-stained quartz with some galena. The country rock here is granodiorite. The vein strikes North 30° West and dips 70° Northeast. A small side-vein lies a little to the east of this. A shaft about eight feet deep has been sunk upon it in granite. This vein seems to trend about North 80° East. Seventy-five feet west there is another opening upon the side-vein. The White Tail vein outcrops again at the north center end-line as a vein composed of quartz disseminated in a belt of granodiorite about 15 feet in width. Open trenches have been cut across it and show considerable galena impregnated through the mass. The country rock is entirely granodiorite. An assay of a sample taken from the shaft 150 feet west of the discovery shaft gives 0.01 oz. of gold, and 1.20 oz. of silver to the ton.

BLACK TAIL.

The Black Tail claim lies in the south central part of Section 36, Township 32 North, Range 36 East, a little over one-half

mile northeast of Covada postoffice. It was located in April, 1911. The country rock is entirely granodiorite. The discovery is situated 50 feet from the south center end-line. A shaft has been sunk on the vein to a depth of 12 feet. The vein is about four feet thick in places, but here and there seems to be only a silicified zone in the granodiorite. It strikes North 30° West and dips 70° Northeast. Several small cuts and pits have been made along the vein in the near vicinity. About 300 feet from the end-line and near the west side-line there is a narrow stringer of quartz about four inches wide containing some galena. An average sample from the discovery shaft on this claim yields through the assay a trace of gold and 0.20 oz. of silver to the ton.

BUTTERFLY.

The Butterfly claim is situated about one-half mile east of Covada postoffice and joins the Black Tail on the north. The discovery shaft of this claim is located about 200 feet north of the south end-line. The shaft is 13 feet deep and in granite. The vein, consisting of iron-stained quartz, varies in width from four inches to one foot and is nearly vertical. About 100 feet east of the discovery shaft a tunnel is being driven as a crosscut to the vein. At present it extends 200 feet and is entirely in quartzite. One hundred and twenty feet from the mouth a small, narrow vein of quartz was encountered. The main discovery vein has not yet been reached. About 25 feet southeast from the discovery shaft an open cut 12 feet long and six feet deep has been made in granodiorite, but no quartz vein was seen. The main contact between the granodiorite and quartzite is near the discovery shaft. Fifty feet south of the discovery an open cut 25 feet long and four feet deep has been made, exposing the main vein. The assay of an average sample from the discovery vein shows 0.01 oz. of gold and 0.30 oz. of silver per ton.

SUNSHINE.

This claim lies just east of and parallel to the Butterfly and a little less than one-half mile east of Covada postoffice. It was located in April, 1912. The discovery shaft lies 250 feet north

of the south center end-line and two shafts about 10 feet apart have been sunk in granodiorite to a depth of 10 feet each. The vein is quartz, about four feet wide, having a strike of North 15° East and a dip of 70° to the East. In places it seems to be merely a zone of silicified granodiorite. An open cut 10 feet long, four feet wide and six feet deep has been made 50 feet north from the south center end of the claim, exposing vein matter about two feet wide. The country rock is entirely granodiorite. The assay of an average sample from the discovery shows no gold and only a trace of silver.

I. X. L.

This claim lies in Section 1, Township 31 North, Range 36 East, about one-half mile southeast of Covada postoffice. It is now owned by James Hartwell of Covada. The discovery shaft on this claim is 100 feet south of the north center end-line. The country rock is quartzite. The vein consists of quartz and at this point is three feet wide, striking North 20° West with a nearly vertical dip. Seven hundred and fifty feet from the discovery shaft and 150 feet from the west side-line a crosscut tunnel has been driven 63 feet in a direction North 80° West to tap the vein. The assay from an average sample from the discovery shows 0.36 oz. of gold and 0.24 oz. of silver per ton.

SUNSET.

The Sunset claim was located in March, 1912, by T. B. Miller. It lies parallel to and on the east side of the I. X. L., a little over one-half mile east of Covada. The discovery shaft is situated 25 feet from the north center end-line and has been sunk to a depth of 14 feet in quartzite. The vein consists of small stringers of quartz. Small apophyses of granodiorite extend up into the quartzite near the contact, which is not far from the discovery shaft. This is the only development work upon the claim. The assay for an average sample from the discovery of this claim showed a trace of gold and 0.30 oz. of silver per ton.

OLD NELL.

This claim is situated in the northwest quarter of the southeast quarter of Section 36, Township 32 North, Range 36 East, about three-fourths of a mile northeast of Covada postoffice. The discovery lies 350 feet from the south central end-line. A shaft has been sunk seven feet in granodiorite exposing a vein of quartz. About 800 feet from the north end-line on the main vein a second open cut has been made about eight feet long and four feet deep. Stringers of quartz were encountered in quartzite. When this cut was first made it is said to have carried much native antimony. A tunnel has been started at a point 150 feet east of the center and 350 feet from the north center end running into the hill South 65° East for a distance of 25 feet. The country rock is silicified quartzite. This lies near the granodiorite contact and is referred to by the miners as a porphyry dike. A sample taken from the open cut in the center of the claim yielded, upon assaying, trace of gold and 0.20 oz. of silver per ton.

POLARIS.

This claim was located in July, 1903, by Henry Garrett and H. P. Stevenson. It is situated in the east central part of Section 36, Township 32 North, Range 37 East, about three-quarters of a mile east of Covada postoffice. The discovery shaft is located 584 feet south of the north end-line and has been sunk to a depth of 20 feet. A tunnel has been driven north and south towards the shaft. A large amount of trenching has been done just north of the shaft. About 75 feet west of the discovery is a shaft seven feet deep, sunk on a quartz vein eight inches in width, trending east and west and dipping vertically. The country rock is granodiorite. At a point North 20° East from the shaft a tunnel starts into the hill North 85° East and continues for 100 feet as a crosscut through granodiorite to tap the vein. Several other openings have been made on the vein by open cuts and pits. An average sample from this claim upon assaying showed a trace of gold and 0.20 oz. of silver to the ton.

BIG JOKER.

The Big Joker lies parallel to and just east of the Polaris, near the east line of Section 36, Township 32 North, Range 36 East. It was located in 1909 and is now owned by Mr. Messenger of Covada. The discovery is located 300 feet north of the south end-line in quartzite. A shaft has been sunk to a depth of 12 feet, showing a vein of iron-stained quartz about two feet wide, striking North 10° East and dipping 50° to the Southeast. Eighty feet in a direction South 40° East from the discovery there is a shaft eight feet deep, ten feet long and five feet wide in quartzite. The vein, which is a side lead, is three feet wide, trends North 80° West and dips 70° Southwest. There are 12 inches of good quartz containing galena and pyrite. The country rock is much silicified nearby, probably due to the proximity of the quartzite granodiorite contact. On the west side of the claim several pits have been sunk on a quartz vein with vertical dip. It averages 26 inches in width. Several shallow shafts have been sunk on a small, narrow vein in quartzite 300 feet from the south end-line. An open cut 25 feet long and 10 feet deep has been made in the granodiorite 300 feet from the north end-line in the west side. It cuts a pyrite-bearing quartz vein dipping 20° west. Forty feet east a shaft 10 feet long and four feet wide has been sunk to a depth of 10 feet in quartzite on a vein similar to the one just mentioned. This lies on the contact between the granodiorite and quartzite. Several openings have been made upon this contact vein.

KENTUCKY BELL.

The Kentucky Bell is now owned by J. C. Seaman of Covada. It is situated in the southeast quarter of Section 36, Township 32 North, nearly one mile east of Covada postoffice. The discovery lies 150 feet north of the south center end-line and is now caved in. Three hundred feet from the end-line is a 30-foot shaft sunk as a slope 70° East on the discovery vein, which is 18 inches wide and consists of iron-stained quartz. The country rock is quartzite. At the bottom of the shaft there is a short crosscut to the east. About 50 feet north of the slope on

the same vein there is an open cut showing the vein to have a width of 18 inches. The granite-quartzite contact lies a little to the west of the discovery. On the west side-line of the claim, 600 feet south of the northwest corner-stake, a crosscut tunnel starts into the hill North 80° East in quartzite. The granodiorite contact lies just west of the mouth. This tunnel intersects the vein at 400 feet and is extended 93 feet farther. The vein where tapped is six feet wide, consisting of quartz and gouge material. Drifts to the right and left extend about 25 feet in the direction North 20° East. Three hundred and twenty-five feet from the mouth a vein was encountered. On it a drift to the left runs North 18° West for 25 feet and to the right due south 15 feet. Several pits have been sunk on the vein at the surface.

THREE PINES.

This claim lies immediately south of the Old Nell. It is situated about three-quarters of a mile east of Covada postoffice in the southeast quarter of Section 36, Township 32 North, Range 36 East. The discovery shaft is 10 feet deep and sunk in granodiorite. The vein is composed of quartz with galena. It has a thickness of 16 inches, strikes north and south and dips 45° west. This shaft is located 100 feet south of the north center end-line. The assessment work for this claim has been done on the Kentucky Bell.

SILVER DOLLAR.

The Silver Dollar lies immediately south of the Kentucky Bell. It is situated in the northeast quarter of Section 1, Township 32 North, Range 36 East. The discovery shaft is 108 feet south of the north center end and has been sunk eight feet in granodiorite, showing a quartz vein trending north and south. The assessment work for this claim has been done on the Kentucky Bell.

SUMMIT.

The Summit claim lies in the southeast quarter of Section 36, Township 32 North, Range 36 East, east of and parallel to the Silver Dollar and Kentucky Bell. The discovery shaft is situated 270 feet north of the south center end-line. It is now caved in,

but shows a ledge of white quartz, iron-stained in places. Seventy-five feet north of the discovery is a shaft 15 feet deep in quartzite showing a vein of quartz carrying pyrite, antimony and galena. The bedding of the quartzite here is North 40° West with a vertical dip. On the east side-line 400 feet south of the northeast corner is a shaft 25 feet deep. The vein is six inches wide, strikes North 85° East and dips 70° Northwest. On the side-line 200 feet north from the southwest corner is a shaft 20 feet deep in quartzite. The Summit claim is 300 feet wide at the south end and 600 feet at the north.

SILVER CROWN NO. 3.

The Silver Crown No. 3 is a small triangular shaped claim lying in the northeast quarter of Section 1, Township 36 North, Range 36 East, nearly one mile east of Covada postoffice. It lies just east of and parallel to the Silver Dollar. It was located in 1909 and is now owned by Mr. Howe of Covada. The discovery shaft is situated 175 feet south of the north end-line and has been sunk to a depth of 12 feet in quartzite. The vein has an average width of six inches, strikes North 10° West and dips 70° Northeast. The gangue is quartz showing considerable galena. A sample from the discovery shaft shows upon assaying 0.02 oz. of gold and 0.60 oz. of silver to the ton.

SILVER CROWN NO. 2.

This claim lies just east of and parallel to Silver Crown No. 3, about one mile east of Covada postoffice. It was located in 1909 and is now owned by Mr. Howe of Covada. Considerable development work has been done. The discovery shaft is located 575 feet from the north center-line and has been sunk to a depth of 10 feet. Forty-five feet in the direction South 75° East from the shaft is the mouth of a tunnel which extends into the hill 85 feet in a direction North 75° West. Thirty feet from the shaft in a direction North 80° West is the surface opening of an upraise from the fifty-foot level. A short distance from the discovery shaft is the entrance to the main shaft reaching the 50-foot level. At the intersection of shaft and vein on the

50-foot level a drift extends to the left for 40 feet in the direction South 70° West. Here the vein dips 60° Northwest. At the face of the drift a vein four feet wide, trending North 15° West and dipping 45° Northeast was encountered. A drift has been run on this to the south for 10 feet and to the north for 20 feet and a raise has been made from it to the surface. A sample taken here assayed 0.04 oz. of gold and 16.10 oz. silver per ton. From the shaft on the 50-foot level a drift has been run to the right along the vein for 25 feet. The country rock is quartzite with a strike of North 15° West and a dip of 60° Northeast. The shaft extends 50 feet farther and at the 100-foot level some drifting has been done. At a point 150 feet from the north end-line of the claim and 100 feet east of the center-line an open cut 10 feet long by seven deep and four wide has been made in the quartzite.

SILVER CROWN NO. 1.

This claim lies just east of Silver Crown No. 2 on the steep slope leading down to the Columbia River in the northwest quarter of Section 6, Township 31 North, Range 37 East. It was located in 1909 and is now owned by Mr. Howe of Covada. The discovery shaft is situated 50 feet from the south end-line. It is 12 feet deep and has been sunk on a three-foot seam of quartz and gouge material. On the hillside 150 feet from the northeast corner and 50 feet from the side-line a tunnel has been run North 55° West for 125 feet as a crosscut through quartzite and limestone. A short distance from the mouth is a vein of quartz 12 inches wide. At the face a vein was encountered about 14 inches wide with a strike of North 15° West and a dip of 75° Southwest. Seventy-five feet south of the tunnel two open cuts have been made in the quartzite and limestone. About half way between the end lines and 100 feet from the east side-line a cut 15 feet long, ten feet deep and four feet wide has been made. The rock is quartzite with seams of quartz about four inches wide. Two similar cuts occur about 100 feet to the southeast. Here the vein strikes North 43° West, with

nearly vertical dip. It consists of 16 inches of solid quartz with some pyrite and antimony.

IDORA.

The Idora lies in the east central part of Section 1, Township 32 North, Range 36 East, and south of the Silver Dollar. It is now owned by James Hartwell. The discovery shaft, 300 feet from the south center end-line, has been sunk to a depth of nine feet in quartzite. The quartz vein is about four inches thick, strikes North 30° West and dips 45° Northeast. Scattered through it are grains of galena. It outcrops at intervals upon the surface. Two hundred feet from the west side-line and 300 feet from the north end-line a crosscut has been driven into the hill 60 feet in the direction North 80° East. At the face is a zone of silicified quartzite with stringers of quartz containing galena. The main vein has probably not been reached.

OHIO.

The Ohio claim lies just south of the center of Section 26, Township 32 North, Range 36 East, about one and one-half miles northwest of Covada postoffice. It is now owned by Mr. M. H. O'Connel of Covada. The discovery shaft is 200 feet from the southwest end-line and is in granodiorite, which is the country rock throughout the entire claim. A tunnel has been run for a distance of 150 feet in a direction South 70° West along a vein four inches wide and composed of solid quartz with pyrite and a little galena. This is said to be a side vein parallel to the main one of the claim.

DRUMMOND.

The Drummond lies parallel to and just south of the Ohio, a little less than one and one-half miles north of Covada postoffice. It is at present owned by Mr. M. H. O'Connel of Covada. The discovery shaft, 750 feet from the north end-line, has been sunk 10 feet and a vein of white quartz two feet wide is exposed, showing pyrite, galena and sphalerite. The country rock is granodiorite. About 50 feet south a tunnel has been run into

the mountain 95 feet as a crosscut in the direction North 30° West. At the face a drift runs 30 feet to the east and 11 feet to the west on a vein of crushed quartz. Pyrite and galena are quite abundantly scattered through the quartz. Several open cuts have been made at various places on the claim. A sample taken from the face of the drift in the tunnel yielded upon assaying 0.02 oz. of gold and 1.20 oz. of silver to the ton.

CHANCE.

This claim lies on the hillside just west of Covada Lake. The discovery shaft, situated 250 feet from the northeast end-line, has been sunk to a depth of 22 feet in granodiorite. The vein, composed of quartz, is eight inches thick, strikes North 40° East and dips 70° Southeast. This is the only opening on the claim except a small shaft eight feet deep, 100 feet to the southwest. An average sample from the discovery shaft showed upon assaying 0.02 oz. of gold and 1.60 oz. of silver to the ton.

ROYAL ANN NO. 1.

This claim is located in the southwest quarter of Section 26, Township 32 North, Range 36 East, a little over a mile northwest of Covada postoffice. It was located in 1904 and is now owned by C. C. Rohlfs of Covada. At a point 800 feet from the east end-line a crosscut tunnel extends southward 75 feet into the hill toward the vein. The country rock is granodiorite. At the face of the crosscut there are two parallel veins running approximately in an east-west direction and consisting of quartz rich in galena and pyrite. The veins together average about one foot in thickness, with a dip to the south and southwest. An assay of an average sample taken here showed 0.04 oz. of gold and 12.50 oz. of silver to the ton. Another tunnel, extending South 40° West, has been driven 110 feet. Fifty feet from the mouth a drift has been run along a vein to the left. To the right another extends 72 feet in the direction South 85° West. At the face of the crosscut a drift extends to the right and left for 25 feet in the direction South 40° East. The discovery shaft is on open cut 25 feet long, 15 feet deep and four feet wide.

The vein is eight inches wide with small stringers along the side. The gangue is quartz containing considerable amounts of galena, sphalerite, cerusite and pyrite. About 40 feet east of the discovery there is an open trench 30 feet long and six feet deep. The country rock is entirely granodiorite.

ROYAL ANN NO. 2.

This claim lies just south of Royal Ann No. 1. It was located in 1904 and is now owned by C. C. Rohlfs of Covada. The discovery shaft, located 50 feet from the east end-line, has been sunk 12 feet in granodiorite with gneissoid structure. The assessment work for this claim has been done on the Royal Ann No. 1.

ROYAL ANN NO. 3.

This claim lies about one mile to the northwest of Covada postoffice and a little to the southwest of Royal Ann No. 2. It also is owned by C. C. Rohlfs of Covada. The discovery shaft, 735 feet east from the west end-line, has been sunk 10 feet in granodiorite. The vein, which is six inches wide, consists of well mineralized quartz. An average sample from here yields upon assaying 0.02 oz. of gold and 3.20 oz. of silver to the ton. One hundred and fifty feet east of the discovery a shaft has been sunk on the vein to a depth of 40 feet. The country rock is granodiorite. The vein ranges from 10 to 16 inches in width, strikes North 70° East and dips 75° Northwest. A cabin is built over this shaft. One hundred and fifty feet from the west end-line and 150 feet from the south side-line there is a shaft 30 feet deep in granodiorite. The quartz vein is of the same character as before and contains considerable galena.

RELIANCE.

This claim lies just north of the Greasy Run, about 1,000 feet north of Covada. The 10-foot discovery shaft is situated 300 feet from the north end-line. The country rock is schistose quartzite near the granodiorite contact. The vein consists of quartz eight inches wide with a strike of North 80° West and a vertical dip. An average sample from the discovery shaft yields upon assaying a trace of gold and 0.20 oz. of silver to the ton.

SILVER PLUME.

This claim lies just west of the Greasy Run and about 1,000 feet northwest of Covada postoffice. It is now owned by Mr. J. M. Anderson of Covada. The discovery shaft is located 100 feet north of the south end-line. The country rock is schistose quartzite. The vein strikes north and south and dips 50° to the west.

SILVER SPAR.

This claim joins the south end of the Legal Tender claim of the Big Chief Group, and is about 1,500 feet north of Covada postoffice. It was located in 1907 and is now owned by Mr. A. M. Anderson of Covada. The discovery shaft, located 350 feet from the south end-line, has been sunk 12 feet in quartzite. The vein of quartz is 12 inches wide, strikes north and south, and has a vertical dip.

LEGAL TENDER.

This claim lies just west of Covada Lake on the slope of the ridge and about one-half mile north of Covada postoffice. It was located in March, 1910, and is now owned by A. M. Anderson of Covada. The discovery shaft is 250 feet from the north end-line and is eight feet deep. The vein consists of a mixture of quartz and mineralized country rock, about three feet wide and containing galena, pyrite and sphalerite. The vein strikes North 20° East and dips 60° Northwest. This claim lies against the east side-line of the Carbonate Chief claim, one of the Big Chief Group, which is patented.

LONE PINE.

This claim lies about one-half mile northwest of Covada postoffice. It was located in July, 1912, and is owned by Mr. Edward Sizemore of Covada. The discovery is 600 feet from the north center end-line. It is an open cut 10 feet long and eight feet deep, in quartzite. Outcrops of quartz show upon the surface.

BIG BUG

The Big Bug claim lies about one-half mile west of Covada in Section 35, Township 32 North, Range 36 East. It was located in 1907 and is now owned by Mr. H. G. Parmeter of Covada.

The discovery shaft is 400 feet northwest from the southeast end-line and is 20 feet deep in quartzite. The vein in the bottom of the shaft is six inches wide, strikes North 65° East and dips 45° Southeast. At a point 1,100 feet from the south center end-line a crosscut tunnel extends into the hill North 60° West, a distance of 50 feet. At the face a four-inch vein of pure quartz trending North 70° East and dipping vertically was encountered. An assay of an average sample taken showed a trace of gold and 0.40 oz. of silver per ton. Nearby there is an open cut 10 feet long and six feet deep. The country rock is quartzite and the vein, which is six inches wide, is the same as in the tunnel. Fifty feet from the discovery shaft in a North 60° West line there is a cut eight feet long and six feet deep showing the quartz vein to be eight inches wide.

COLORADO NO. 1.

This claim is about one mile north of Covada postoffice and joins the north end of the Silver Spray claim of the Advance Group. It was located in 1905 and is owned by Mr. M. H. McConnel of Covada. The discovery shaft is situated 300 feet north of the south center end-line on a steep hillside. The assessment work for this claim has been done on the Colorado No. 2.

COLORADO NO. 2.

The Colorado No. 2 lies parallel to and northwest of the Colorado No. 1. It is owned by Mr. M. H. McConnel of Covada. The discovery is an open cut 12 feet long and eight feet deep and located 100 feet from the south center end. Twenty-five feet to the northeast there is a slope eight feet deep on the vein, which is four feet wide with two feet of ore. Antimony and galena are common. Twenty-five feet farther is another shaft 12 feet deep on the same vein. The country rock here is quartzite. Several open cuts have been made on the vein for the entire length of the claim. At a point 25 feet from the west side-line and 100 feet from the southwest corner a tunnel has been driven South 55° East into the hill as a crosscut to tap the discovery vein. Two hundred and five feet from the mouth a small vein

two feet thick was encountered, which has been drifted upon for 50 feet. The discovery vein has not as yet been reached. The contact between the granodiorite and quartzite occurs here. An average sample taken from the tunnel 25 feet south of the discovery tunnel yields in the assay a trace of gold and 0.60 oz. of silver per ton.

BLACK HAWK.

This claim lies parallel to and on the north side of the Royal Ann No. 1, about one and one-quarter miles north of Covada postoffice. It was located in April, 1905, and is now owned by Mr. Kelley of Covada. At a point near the north side-line, 600 feet from the southeast corner of the claim, a tunnel has been driven South 35° West into the hill a distance of 60 feet on a vein of quartz eight inches wide with a vertical dip. The country rock is granite. On the southwest corner of the claim is an open cut 12 feet deep and 25 feet long. The vein exposed in it is a side lead about one foot wide and carrying a considerable amount of galena and antimony. Two hundred feet from the southwest end-line a tunnel has been driven on the discovery vein North 70° West, a distance of 80 feet. The vein is one foot wide and consists of white massive quartz containing galena, pyrite and sphalerite. An average sample from this vein assayed 0.03 oz. of gold and 3.30 oz. of silver per ton. A parallel tunnel 70 feet in length lies about 10 feet away.

JOKER.

This short claim, located in 1909, joins the west end of the Black Hawk. The discovery shaft is situated about 170 feet from the southwest end-line and has been sunk 10 feet in granodiorite on a quartz vein eight inches wide. The vein strikes North 70° West and has a vertical dip. An average sample from this vein yielded in the assay neither gold nor silver. At the east center end-line of the claim a cut 30 feet long has been made in the granodiorite, exposing the discovery vein one foot thick with a strike of North 70° West and a vertical dip.

DISCOVERY.

This claim is situated near the Black Hawk, about one and one-quarter miles northwest of Covada postoffice. The discovery is an open cut in granodiorite on a quartz vein which may be a continuation of the side vein of the Black Hawk. The cut is 10 feet deep and 15 feet long. The vein is about seven inches wide, strikes North 80° West and dips 70° Northwest. It is situated 200 feet from the southwest end-line.

LITTLE JAY.

This claim is situated in the southwest quarter of Section 26, Township 32 North, Range 36 East, about one mile northwest of Covada postoffice. The discovery shaft is in granodiorite 10 feet deep on a vein striking North 83° West and dipping vertically. The vein is eight inches wide. Two hundred feet from the west end-line is an open cut 10 feet long and eight feet deep in granodiorite exposing a quartz vein eight inches wide with a vertical dip and striking North 80° East. An average sample taken from the discovery shaft yielded in the assay a trace of gold and 0.20 oz. of silver to the ton.

CHEROKEE STRIP.

This claim is situated in the southwest quarter of Section 31, Township 32 North, Range 37 East, about one and one-half miles east of Covada. It was located in 1906 and is owned by Mr. L. G. Curry of Covada. The discovery shaft is located 150 feet from the north center end-line and is 12 feet deep. The vein strikes north and south and dips 80° to the east. The formation here consists of banded quartzite. The assay of an average sample taken here shows a trace of gold and 0.20 oz. of silver per ton. This claim is not in contest and no further examination was made on it.

NORTHERN LIGHT.

The Northern Light is situated in the northeast quarter of Section 31, Township 32 North, Range 37 East, one and three-fourths miles east from Covada. The discovery shaft, 10 feet

run eastward 60 feet, cutting a vein which strikes North 80° East and dips 80° West. The vein is about six inches wide in a much decomposed granodiorite. Considerable galena is present with some pyrite. An open cut nearby, 15 feet long and eight feet deep, exposes the vein striking North 80° West and dipping 80° Northeast, and having a width of eight inches. Some galena is present. The discovery shaft is 50 feet deep and has been sunk on the vein.

ST. PATRICK.

The claim is parallel to and on the north side of the Oom Paul, one and one-half miles northwest of Covada postoffice. It was located in 1907 and is now owned by Mr. Kelly of Covada. The discovery shaft, which is 16 feet deep, is situated on the hillside above the mouth of the tunnel and 150 feet from the side-line. The vein is a mixture of quartz and talc three feet thick. The tunnel just referred to starts near the south side-line and 400 feet from the west line as a crosscut and extends into the hill North 55° West, a distance of 70 feet, but the vein in the discovery shaft has not been reached. One hundred and fifty feet west of the discovery, a shaft has been sunk on the vein in quartzite. The vein here is four inches wide, strikes North 80° East and dips vertically. It consists of quartz with galena and pyrite. An average sample, upon assaying, showed 0.03 oz. of gold and 2.00 oz. of silver per ton.

ETTA.

The Etta is a trangular shaped claim lying parallel to and just south of the Oom Paul, about one and one-quarter miles north of Covada postoffice. The discovery shaft is 60 feet deep. Thirty-five feet down a drift has been driven due west 15 feet on a vein trending east and west and dipping 70° north. On the 60-foot level at the bottom of the shaft another drift has been driven due north 20 feet along a vein. The country rock is granodiorite. About 50 feet west of the discovery shaft another shaft has been sunk six feet on a vein 14 inches wide containing galena and pyrite. An assay of an average sample taken here showed a trace of gold and 0.30 oz. of silver to the ton.

Near the west end and south of the claim a crosscut tunnel has been driven to tap the discovery vein. It extends into the hill North 40° West a distance of 35 feet in granodiorite and cuts a small side vein of quartz containing galena.

SEVERAL FRACTION.

The claim lies in the southeast quarter of Section 27, Township 32 North, Range 36 East, about one and one-quarter miles northwest of Covada postoffice. It is owned by G. A. Mathews of Covada. The discovery shaft is 20 feet deep and in granodiorite. The vein is four inches wide, strikes North 80° East and dips nearly vertically. The vein is quartz carrying galena and pyrite. Fifty feet away there are two shallow shafts, each six feet deep. Several open cuts have been made.

SILVER SPAR.

This claim is situated in the northeast corner of Section 27, Township 32 North, Range 36 East, nearly two miles northwest of Covada postoffice. It was located in January, 1907, and is a part of the Imperial Group. It is owned by G. E. Terpening of Covada. The discovery lies 400 feet north from the south end-line and is in granodiorite. Two hundred feet in the direction South 25° West from the discovery is a shaft 20 feet deep on a ledge in granodiorite. There are several open cuts in addition. The vein, about 18 inches wide, consists of calcite with some quartz.

GOOD ORE.

The claim lies in the southeast quarter of Section 22, Township 32 North, Range 36 East, about two and one-half miles northwest of Covada postoffice. It is now owned by G. E. Terpening of Covada. The discovery shaft is 10 feet deep in granodiorite. The vein strikes South 60° West, dips 60° Southeast and comprises a zone two feet wide of crushed and much altered quartz and country rock. A crosscut tunnel has been driven 140 feet toward the vein in the direction South 55° East. One hundred feet from the mouth a vein of quartz six inches wide was encountered. Several open cuts and short

tunnels have been made, and wherever the vein was cut the same strike, North 60° East, prevailed.

SEVERAL.

This claim lies due west of the Oom Paul in the south central part of Section 27, Township 32 North, Range 36 East. It is owned by G. E. Terpening of Covada. The discovery shaft, which is 12 feet deep, and in granodiorite, shows a vein one foot wide with well defined walls striking North 55° East and dipping 60 ° Southwest. A sample taken here yielded in the assay a trace of gold and 1.00 oz. of silver per ton. A tunnel has been driven as a drift on what is supposed to be the discovery vein a distance of over 360 feet. The country rock is entirely granodiorite.

BLACK THORN.

The claim is situated about one and one-half miles northwest of Covada postoffice in the southern part of Section 27, Township 32 North, Range 36 East, in Stray Dog Canyon. It is owned by the Black Thorn Mining Company. The discovery opening is a 15-foot tunnel running due north into the side of the canyon. The vein is six inches wide and dips 75° East. The assay of a sample taken here showed 0.04 oz. of gold and 1.40 oz. of silver to the ton. A tunnel has also been driven into the side of the hill toward the vein a distance of 285 feet. The first 200 feet passed through loose boulders of the talus slope. At the face, the vein is eight inches wide. The country rock is entirely granodiorite.

KEYSTONE.

This is one of the Keystone Group consisting of eight claims. It lies in the eastern part of Section 34 about one mile northwest from Covada postoffice, in Stray Dog Canyon. It is owned by G. A. Mathews of Covada. A tunnel has been driven as a drift on the Keystone claim 600 feet in the direction South 45° West. The country rock is quartzite. The vein is well defined, pitches 45° to the Northwest and varies in width from six inches to two feet. The vein is much crushed and contains galena, sphalerite, pyrite and chalcopyrite.

SYNDICATE.

This claim lies in the northeast quarter of Section 34, Township 32 North, Range 36 East, about one and one-third miles northwest of Covada postoffice. It is owned by J. W. Bartlett of Covada. The country rock is granodiorite. A tunnel has been driven, as a crosscut, 850 feet into the hill in the direction North 58° East. Six hundred feet from the mouth a small vein of very little importance was encountered.

DAN PATCH.

This claim is situated in the southwestern quarter of Section 13, Township 32 North, Range 36 East, about three and one-half miles north of Covada postoffice. It was located in May, 1910, and is now owned by L. G. Curry of Covada. The country rock is entirely quartzite and slate. Near the west end a tunnel has been driven into the hill North 25° East a distance of 54 feet along the vein. The vein pitches 30° to 45° to the northwest and has a total width of three feet, 16 inches of which is quartz. A sample taken from the face of this tunnel showed upon assaying 0.04 oz. of gold and 10.15 oz. of silver per ton. A sample taken from the gray talc here showed a trace of gold and 0.40 oz. of silver per ton. One hundred feet up the hill from the discovery tunnel there are several open cuts exposing a vein trending North 65° East and containing galena and sphalerite. A shaft has been sunk to a depth of 30 feet on a vein trending North 10° West and dipping 70° to the Southwest. It ranges from two to eight inches in thickness and is composed of quartz with some pyrite.

REN RICE.

This claim joins the east end-line of the Dan Patch and is about three and one-half miles north of Covada postoffice. It was located in 1910 and is owned by Mr. L. G. Curry of Covada. The 12-foot discovery shaft is in quartzite and shows a six-inch quartz vein somewhat crushed trending North 68° East. The assay of a sample taken here yielded a trace of gold and 0.30 oz. of silver per ton.

GREAT SCOTT.

The Great Scott lies just south of the Dan Patch, about three and one-half miles north of Covada postoffice. It was located in December, 1911, and is now owned by Mr. Messenger of Covada. The discovery shaft is eight feet deep. Nearby is another shaft nine feet deep with a quartz vein striking North 15° East and dipping 75° to the southeast. Several open cuts have been made. The country rock is entirely composed of quartzite and slate. A sample taken at the discovery shaft showed in the assay a trace of gold and 0.20 oz. silver per ton.

VICTOR.

This claim lies east of the Ren Rice, about four miles northeast of Covada postoffice. It was located in February, 1912. There is one shaft 40 feet deep and timbered. The vein at this point, consisting of yellowish stained quartz, strikes North 15° West and dips 70° to the Southwest. Nearby are several open cuts. The discovery shaft, situated 100 feet from the north end of the claim, is 8 feet deep and shows a vein striking North 15° West and dipping 75° Southwest. The country rock is quartzite. A short distance away is a tunnel 10 feet long. An average sample taken here showed upon assaying 0.01 oz. of gold and 0.50 oz. of silver per ton.

SAINT PAUL.

The Saint Paul joins the Victor and lies about four miles northeast of Covada postoffice. It was located in 1912. The 10-foot discovery shaft is situated 300 feet from the south end of the claim. Twenty feet away an open cut has been made. The country rock is quartzite. The vein, which is the same as that on the Victor claim, strikes North 20° West and dips 75° Southwest. It consists of one foot of solid quartz and four inches of crushed wall rock. An average sample taken here showed in the assay a trace of gold and 0.20 oz. of silver per ton.

JAY BIRD.

This claim lies on the north side of Rattlesnake Mountain, three miles from Covada postoffice. It was located in August,

1904, and is owned by Ira B. Gifford of Inchelium. It joins the Rattlesnake claim on the north end in Section 25. A tunnel has been driven along the vein South 36° East, a distance of 20 feet. The vein, composed of quartz, is four inches thick, strikes north and south, and dips 70° West. This claim is one of a group and the assessment work has been largely done on another claim.

SAINT PAUL.

Saint Paul claim lies on the north side of Rattlesnake Mountain, about two miles northeast of Covada postoffice, on Theodore Berjue's farm. It was located in May, 1911. The discovery shaft is 100 feet south from the north end-line. It has been sunk 10 feet in quartzite on a well-defined eight-inch quartz vein, which strikes North 55° East and dips 75° Southeast. Galena and pyrite are scattered through it. About one foot of the wall rock is well mineralized.

LAUREL.

The Laurel is situated on the north side of Rattlesnake Mountain. The discovery is a small open cut in limestone and quartzite. No very well defined vein was seen, although an irregular seam of quartz extends in various directions through it. The formation strikes North 10° West and dips 60° Northeast.

RATTLER.

This claim is situated on the north side of Rattlesnake Mountain. The discovery tunnel starts 200 feet from the north center end-line and extends South 25° West for 95 feet. At the face there is a vein of much crushed quartz, almost three feet wide. The country rock is quartzite. The assay of an average sample taken here shows a trace of gold and 0.20 oz. of silver per ton. The south end of the claim extends up the mountain side.

ALGONKIAN.

This claim lies on a flat, well-timbered area, one-half mile northwest of Rattlesnake Mountain and about two and one-half miles northeast of Covada postoffice. It was located in 1911 and is now owned by Mr. A. M. Anderson of Covada. The

discovery shaft lies 100 feet west of the east end-line. It is eight feet deep and nearby is an open cut or trench. The country rock is quartzite. The vein, which is about six inches thick, strikes east and west and dips vertically. The assay of an average sample taken from the discovery claim shows 0.06 oz. of gold and 8.20 oz. of silver per ton.

STRAY DOG MINE.

This group of five claims lies in the west half of Section 27, Township 32 North, Range 36 East, two miles northwest of Covada postoffice. It is owned by the Stray Dog Mining Company. A long crosscut has been driven into the hill on the west side of Stray Dog Canyon. Some distance in from the mouth a vein of quartz was encountered and a drift was made upon it. This vein strikes North 20° East, dips 75° Northwest, has a width of six inches, and contains a considerable amount of galena and pyrite. A few hundred feet farther in another vein was encountered and a drift made along it. The vein varies from two to five feet in width and contains galena, pyrite, sphalerite and a little sylvanite. The vein strikes North 30° East and dips 80° to the Northwest. An upper crosscut tunnel has been driven and the two are connected by an upraise. The country rock is granodiorite. This group is not in contest and the investigation was only superficial.

IMPERIAL.

This claim was located in 1903 and is owned by Messrs. Messenger and Terpening of Covada. It lies a little over two miles northwest of Covada postoffice. A tunnel has been opened west of the west end-line and extends South 75° East as a crosscut for 204 feet. Forty feet from the face there is a vein three inches wide, trending north and south and dipping vertically. The vein towards which the tunnel is being run is estimated to be 30 feet from the face. The rock is granodiorite. This claim is not in contest.

CAPTAIN.

The Captain claim was formerly known as the Gold Cup. It lies just west of Stray Dog Canyon in the northwest quarter

of Section 27, Township 32 North, Range 36 East. It was located as the Captain in January, 1912. A tunnel has been driven as a crosscut North 45° West a distance of 40 feet through granodiorite. At the face a vein of calcite occurs, much twisted and broken. Twenty feet above a slope has been sunk on a vein striking east and west and dipping 45° to the South. It is six feet wide and a jumbled mass of calcite and country rock. This claim in not in contest.

WHITE ROSE.

This claim is situated in the northeast quarter of Section 3, Township 32 North, Range 36 East, nearly three miles northwest of Covada. The discovery shaft is near the center of the claim, in quartzite, but close to the contact with the granodiorite. Eight feet away from the discovery there is a shaft 60 feet deep and a 20-foot drift extends east from it. The vein strikes North 20° East and dips vertically.

DIXIE QUEEN.

This claim lies just southwest of the New York claim, in Section 33, Township 32 North, Range 36 East. The discovery shaft is located 700 feet from the north end in quartzite. It exposes a quartz vein two feet wide, striking North 20° East and dipping nearly vertically. A short distance west is another small shaft 10 feet deep.

RESERVE.

This claim is situated in the southeast quarter of Section 33, Township 32 North, Range 36 East, about three miles due west of Covada postoffice. It was located in March, 1905, and is now owned by Mr. L. G. Curry of Covada. The discovery shaft, which is 100 feet from the north end, is 48 feet deep and at the bottom a drift has been run a distance of 75 feet. The country rock is quartzite. The vein consists of seven feet of crushed country rock and three feet of white quartz, containing galena and pyrite. It strikes North 45° East and dips to the northwest. About half way between the end lines on the west side is a ledge of solid white quartz dipping 45° West. An average

sample from the discovery shaft shows, in the assay, 0.04 oz. of gold and 7.80 oz. of silver to the ton.

RUBY.

This claim lies just east of the Reserve and is a part of this group. It is owned by Mr. L. G. Curry of Covada. The 12-foot discovery shaft is in slaty quartzite. The assessment work for the claim has been done on the Reserve claim.

SANTA CLAUS.

The Santa Claus claim lies just west of the Reserve and is a part of the same group. The discovery shaft is a slope 40 feet in length and sunk on a quartz vein striking North 20° East and dipping 50° to the Northwest. The vein is about three feet thick.

NEGLECTED.

The Neglected claim is a part of the Reserve Group and joins the northeast end-line of the Santa Claus. The discovery shaft is 20 feet deep and is in quartzite. The vein strikes North 20° East with a vertical dip. It is about eight inches wide and contains some pyrite and galena. The assay of an average sample taken here shows no gold and only a trace of silver.

MONTANA.

This claim lies in the central part of Section 28, Township 32 North, Range 36 East. It is now owned by Messrs. Fish and Pea. The country rock is granodiorite. A shaft has been sunk to a depth of 90 feet and from the foot a drift has been run to the east. Twenty-five feet farther east a second shaft has been sunk to a depth of 20 feet.

ADMIRAL.

The Admiral claim is situated in the northeast quarter of Section 28, Township 32 North, Range 36 East. It is owned by Mr. Joseph Hartwell of Covada. At the discovery a slope has been sunk 30 feet on a vein eight inches thick. Another shaft some distance to the east is 20 feet deep. The country rock is granodiorite.

SNOWSTORM.

This claim was formerly known as the White Swan. It is situated in the east central part of Section 28, Township 32 North, Range 36 East, about two and one-half miles northwest of Covada postoffice. It was located in April, 1912, and is now owned by Messrs. Sizemore and Mathews of Covada. The discovery shaft is 500 feet from the east center end and has been sunk 10 feet in the granodiorite. The vein is very narrow, strikes North 80° East and dips 65° to the Southeast. Fifty feet west of the discovery is a shaft 15 feet deep. Here the vein strikes North 80° East and dips 45° Southeast. The assay of a sample taken here shows a trace of gold and 0.30 oz. of silver to the ton. Some distance from here a crosscut tunnel has been driven 600 feet to the vein and a drift of 100 feet made along the vein. From here both a winze and upraise have been made, the latter to the surface. The vein strikes North 30° East, and dips 70° to the Northwest. The country rock is granodiorite.

TRUAX.

The Truax claim lies in the southwest quarter of Section 22, Township 32 North, Range 36 East, about two and one-half miles from Covada postoffice. It is owned by Mr. M. H. O'Connell of Covada. The discovery shaft lies in the center of the claim. There are two veins here lying close together which have been exposed in a series of open cuts. The country rock is granodiorite, into which a crosscut tunnel has been driven South 25° East a distance of 143 feet to tap the vein.

DEAD SHOT.

This claim belongs to the Golden Treasure Company and is situated about two miles northwest of Covada. There are two veins on the claim. On one of these a tunnel has been driven a distance of 20 feet along what is supposed to be an extension of the Black Thorn vein. The other vein trends North 15° East through the granodiorite and has a width of one foot.

JULIET.

This claim was formerly known as the Little Tom, but was relocated by George Eves as the Juliet. It lies about two miles northwest of Covada postoffice. The discovery shaft is about eight feet deep and exposes two intersecting veins of quartz carrying considerable antimony. The assay of a sample taken here shows 0.02 oz. of gold and 3.40 oz. of silver to the ton. Four other openings have been made.

NEW YORK.

The claim lies in the north central part of Section 23, Township 32 North, Range 36 East, about two and one-half miles northwest of Covada postoffice. The country rock is granodiorite. One shaft has been sunk to a depth of 40 feet on a vein of quartz one foot wide and carrying galena, pyrite and a few specks of ruby silver. A building has been erected over the mouth of the shaft, and an engine for hoisting installed. Five hundred feet away a second shaft has been sunk, but is now filled with water. It is said to be 60 feet deep. The claim is not in contest.

RED CHIEF.

This claim is situated in the west central portion of Section 34, Township 32 North, Range 36 East, about two miles northwest of Covada postoffice. The discovery shaft, which lies in the middle of the claim, has been sunk on the vein to a depth of 25 feet. The vein strikes North 50° East, dips 60° Southeast and is four feet wide; 16 inches of this is solid white quartz and the remainder crushed wall rock mineralized with pyrite and galena. The country rock is granodiorite, although the quartzite contact is not far away. There are two smaller shafts on the claim and one tunnel which has been driven as a crosscut South 50° West, a distance of 25 feet.

VERNIE.

The Vernie claim lies in the center of Section 34, Township 32 North, Range 36 East. It was located in 1899 by H. Garrett and W. A. Pea. The country rock is quartzite, but it lies near the granodiorite contact. One tunnel has been driven

South 65° West a distance of 50 feet on a vein dipping 60° Southeast, and having a width of four feet. In places the quartz is impregnated with pyrite, galena and sphalerite. Seventy-five feet west of the tunnel is located the discovery shaft, 10 feet deep. Three hundred feet from the tunnel is another shaft about 40 feet deep.

GRAND VIEW.

This claim lies in Section 3, Township 31 North, Range 36 East, about two miles due west of Covada postoffice. It belongs to the Silver Queen Group, and is owned by Mr. J. C. Seaman of Covada. The country rock is quartzite and slate. A shaft has been sunk to a depth of 80 feet and at the 30-foot level a drift has been driven south 10 feet. The vein strikes North 40° East, dips 70° Southeast and has a width of about four feet. The gangue is quartz with some galena and a little sylvanite. The claim is not in contest.

LAURA S.

This claim was located March 1, 1913, and is now owned by Mr. H. A. Pea and E. J. Sparling. It lies about two miles west of Covada postoffice. The claim was formerly known as the Ada. The discovery shaft is 800 feet from the east end-line and has been sunk to a depth of 40 feet in quartzite. It was filled with water at the time of examination, but the ore lying on the dump at the mouth of the shaft was quartz containing galena, pyrite and many small particles of sylvanite.

DEWEY.

This claim was located in January, 1911, and is owned by Mr. J. Seaman of Covada. It is situated about one and one-half miles southwest of Covada postoffice. The country rock is quartzite and slate cut in places by a dike of andesite. The discovery tunnel is 800 feet from the north end-line of the claim and extends into the hill South 60° West a distance of 25 feet. The vein is about eight inches wide and lies nearly flat, but is probably not in place. A tunnel just above Mr. Seaman's house in the same draw extends into the hill North

60° West a distance of 100 feet, but is in gravel and sand the entire distance. An average sample from the discovery tunnel upon assaying shows no gold and a trace of silver per ton.

SYRACUSE.

The Syracuse claim lies on Reister Mountain about two miles southwest of Covada postoffice. The country rock is quartzite and slate. A 30-foot discovery shaft has been sunk on the vein, which is six feet wide and consists of crushed country rock containing quartz. It strikes North 30° East and dips 60° Northeast. The assay of an average sample taken here shows a trace of gold and 0.20 oz. of silver to the ton. Near the end of Reister Mountain a dike of andesite outcrops, striking north and south and having a width of 20 feet.

PERRY.

The Perry claim is situated about one mile northeast of Covada postoffice in the northeast quarter of Section 36, Township 32 North, Range 36 East. It is now owned by Mr. Joseph Hartwell of Covada. The claim extends north and south. A slope has been sunk to a depth of 42 feet on an east-west vein, supposed to be a continuation of the Toga. It extends down to the north at an angle of 45°. The vein is four feet wide and consists of white quartz, well mineralized. The assay of an average sample taken here shows neither gold nor silver. Twenty-five feet to the north is an open cut on the north-south vein upon which the claim is located. It is rich in antimony and resembles that on the Longstreet vein. The quartzite contact lies nearby. One hundred feet north there is a 10-foot tunnel. Three hundred feet farther north on the hill slope is another open cut in quartzite. It seems to be a zone of mineralized country rock adjacent to the contact. Twenty-five feet north of this cut is a 10-foot tunnel run as a crosscut to this mineralized zone. Several other open cuts have been made at intervals.

SILVER LEAF.

There are several claims in this group. They are not in contest and only a hasty examination was made. The Silver

Leaf lies on the south side of Rattlesnake Mountain in Section 30, Township 32 North, Range 37 East, about two miles northeast of Covada. It is owned by the Silver Leaf Mining Company of Covada. A tunnel has been driven in a distance of 242 feet through quartzite to the face. Some distance to the west a large opening has been made in the side of the mountain. The country rock is quartzite and highly silicified. One zone is mineralized with quartz, galena and sphalerite. It is said to assay high in silver. The vein as well as formation strikes north and south with vertical dip. At the bottom of the glory hole a shaft has been sunk 30 feet on the vein. Near the base of the shaft the vein is locally cut by a fault. Sphalerite is abundant. The tunnel on this claim is 350 feet north of the south center end-line.

BUFFALO.

The Buffalo claim lies on the slope of Columbia River east of the Ivanhoe Group. It is owned by Mr. Thompson of Covada. Two ledges are found in the slaty schist and calcareous quartzite of the claim. The discovery is close to the river on a vein striking North 80° West and dipping 45° to the Northeast, and having a width of two feet. The assay of an average sample taken here shows a trace of gold and 0.20 oz. of silver to the ton.

ROSARIO.

The Rosario lies in the northwest corner of Section 31, Township 32 North, Range 37 East, a little over one mile northeast of Covada postoffice. It is owned by Mr. George Terpening of Covada. At the discovery a crosscut tunnel has been driven North 70° West a distance of 320 feet. Farther north on the claim another tunnel has been driven in North 60° West a distance of 50 feet on a zone of crushed and mineralized country rock.

GUIN MINE.

This property consists of ten claims located in Section 11, Township 32 North, Range 36 East. They are the Guin, Sunnyside, Homestead, Wizard, Big Pet, Missing Link, Hall

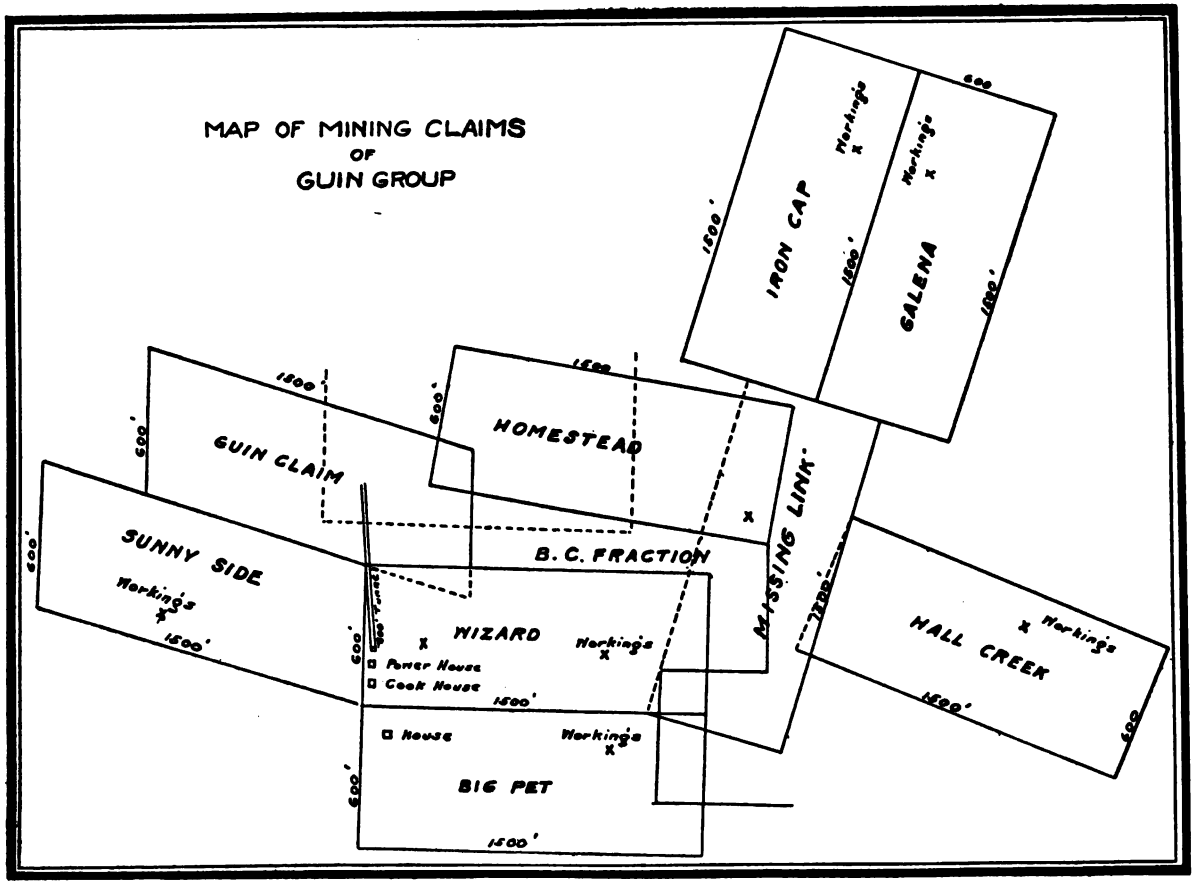

FIG. 8. Map showing mining claims and underground workings of the Guin Mine.

Creek, Galena, Iron Cap and B. C. Fraction. Considerable development work has been done on this property and chiefly on the Wizard and Guin claims. A crosscut tunnel starts near the west center end-line of the Wizard claim and extends a distance of 800 feet into the Guin claim. Four hundred feet from the mouth a vein was encountered striking North 10° East and dipping 20° to the Southeast. Drifts have been made to the left and right. On the right-hand drift a slope has been sunk on the vein a distance of 180 feet on a 45° slope. The vein in the bottom is about 10 feet wide and consists of white quartz. The country rock is quartzite. Assays of two average samples taken here showed in one case 0.08 oz. of gold and 34.50 oz. of silver; and in the other 0.07 oz. of gold and 25.50 oz. of silver to the ton.

On the Guin claim a shaft has been sunk on the vein to a depth of 150 feet. There are 250 feet of workings on the 130-foot level, 250 feet on the 150-foot level and 100 feet on the 100-foot level. The vein is six feet wide on the 100-foot level.

On the Missing Link a quartz vein outcrops in quartzite and upon it a 10-foot shaft has been sunk. On the Galena claim a shaft has been sunk to a depth of 17 feet on a quartz vein three feet wide. It is well mineralized with galena and pyrite. There are also two tunnels 100 and 150 feet in length driven as crosscuts to the vein. Open cuts and short tunnels have been opened on the other claims, but the greater part of the assessment work for the group has been performed on the Wizard and Guin claims. At the time of the examination two shifts of men were working on the vein in the slope.

BIG CHIEF GROUP.

The Big Chief Group consists of six claims situated west and northwest of Covada Lake in Section 35, Township 32 North, Range 36 East. They are the Ripsaw, Jennie C., Little Pet, Apex, Carbonate Chief and Legal Tender. The group was formerly known as the Apex. It was located in 1898 by Edgar Balling and is now owned by the Big Chief Mining Company, of which J. C. Harcleroad of Spokane is president. This group

is not in contest and because of insufficient time no extensive investigation of the properties was undertaken. Several long crosscut tunnels have been driven in the quartzite to the vein. In addition, shafts have been sunk from which at different levels drifts have been driven on the veins. A considerable amount of development work has since been done on this property.

METEOR GROUP.

The Meteor Group of claims are situated about three miles due west of Covada postoffice in Section 33, Township 32 North, Range 36 East. There are four claims altogether, viz., the Peoria, Ohio Fraction, Meteor and Comet. These were located in 1900 by Edgar Balling and are now owned by the Meteor Mining Company, of which W. A. Halteman of Spokane is manager. A large amount of development work has been done but as the group is not in contest no extensive examination was made. One long tunnel has been driven on the Meteor claim on a quartz vein over three feet wide. This has been drifted upon and stoping has been carried upwards for some distance toward the surface. The country rock is quartzite. On the surface several openings have been made and a deep shaft sunk with considerable drifting at different levels.

Other properties in this district upon which a considerable amount of work has been done, but which were not visited, are the Cold Springs Group, the Orion Group, the Southern Cross and the Steinger Groups. None of these are in contest and two of them are patented.

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